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AF TECHNICAL REPORT 6145
PART III

THE EXPERIMENTAL MEASUREMENT OF THERMAL CONDUCTIVITIES, SPECIFIC HEATS, AND DENSITIES OF METALLIC, TRANSPARENT, AND PROTECTIVE MATERIALS

Part III

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BATTELLE MEMORIAL INSTITUTE

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WRIGHT AIR DEVELOPMENT CENTER

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EQUIPMENT LABORATORY
CONTRACT No. AF 33(616)-311
PROJECT No. 1367
TASK No. 61299

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Carpenter Litho & Prtg. Co., Springfield, O.
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FOREWORD

This report was prepared by the Battelle Memorial Institute, Columbus, Ohio, on Air Force Contract No. AF 33(616)-311, under Project No. 1367, Task No. 61299, "Thermal Properties of Aircraft Materials", formerly RDO No. 664-805. The work was administered under the direction of the Equipment Laboratory, Directorate of Laboratories, Wright Air Development Center, with Mr. D. M. Patterson and Mr. C. L. Watson as project engineers, in turn.

ABSTRACT

Measurements of the thermal conductivities of white (clear) plate glass, Solex 2808X plate glass, and Solex "S" plate glass from 150 to 450°C, and of clear fused silica (quartz) and Vycor from 150 to 800°C, are reported.

Specific-heat measurements have been made on K-Monel, Inconel, Inconel X, stainless steels Types 301, 316, and 347, and SAE 1010 mild steel from -200 to 850°C.; on magnesium alloy Type AN-M-29 from -200 to 350°C.; on aluminum alloys Types 24S-T4 and 75S-T6 from -200 to 450°C.; on clear fused silica (quartz) and Vycor from -200 to 800°C.; on white (clear) plate glass, Pyrex Type 774 glass, Solex "S" plate glass, and Solex 2808X plate glass from -200 to 500°C.; and on Flexiglass Type AN-P-44A from -200 to 100°C.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

S. T. SMITH
Colonel, USAF
Chief, Equipment Laboratory

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INTRODUCTION

The measurements performed under the present contract AF 33(616)-311 constitute additional measurements of the same type as made under Contracts AF 33(038)-2996 and AF 33(038)-20558 and reported in USAF Technical Reports Nos. 6145-1 and 6145-2, respectively. The purpose of the three projects has been to obtain measurements of thermal conductivity, specific heat, and density of metallic, transparent, and protective materials over a wide range of temperatures for use in heat-transfer calculations on supersonic aircraft and missiles.

SECTION I

TEST MATERIALS

The test materials investigated under the present contract include ten metals and seven transparent solids. The designations and sources of these materials are given in Table 1. More detailed descriptions of chemical compositions and thermal treatments of the metals may be found in Table 1 of USAF Technical Report No. 6145-1[1].

SECTION II

THERMAL CONDUCTIVITY

Methods and Apparatus

The transparent-solids thermal-conductivity apparatus described in USAF Technical Reports No. 6145-1[1] and No. 6145-2[2] has been used in this investigation. A schematic sketch of the apparatus is shown in Figure 1. The apparatus is similar in principle to that developed at the National Bureau of Standards[3] for thermal-conductivity measurements on metals. The present apparatus, instead of being guarded with separate heaters, has a specimen with a large enough area to provide self guarding and has concentric Armco cylinders around the standard for its guard. The thermal conductivity of the sample is calculated from the areas and temperature gradients of the sample and the standard and the known thermal conductivity of the standard. Armco iron is used as the standard.

TABLE 1. DESIGNATION AND SOURCE OF TEST MATERIALS

Material	Source
Metals	
K-Monel	International Nickel Company
Inconel	International Nickel Company
Inconel X	International Nickel Company
Stainless steel Type 301	Republic Steel Corporation
Stainless steel Type 316	Timken Roller Bearing Company
Stainless steel Type 347	Timken Roller Bearing Company
SAE 1010 mild steel	United States Steel Corporation
Magnesium alloy Type AN-M-29	Dow Chemical Company
Aluminum alloy Type 24S-T4	Aluminum Company of America
Aluminum alloy Type 75S-T6	Aluminum Company of America
Transparent Solids	
Clear fused silica (quartz)	Hanovia Chemical Company
Vycor	Corning Glass Works
White (clear) plate glass	Pittsburgh Plate Glass Company
Pyrex clear chemical glass No. 774	Cincinnati Gasket and Packing Co.
Solex "S" plate glass	Pittsburgh Plate Glass Company
Solex 2808X plate glass	Pittsburgh Plate Glass Company
Plexiglass, AN-P-44A, aircraft quality	Rohm and Haas Chemical Company

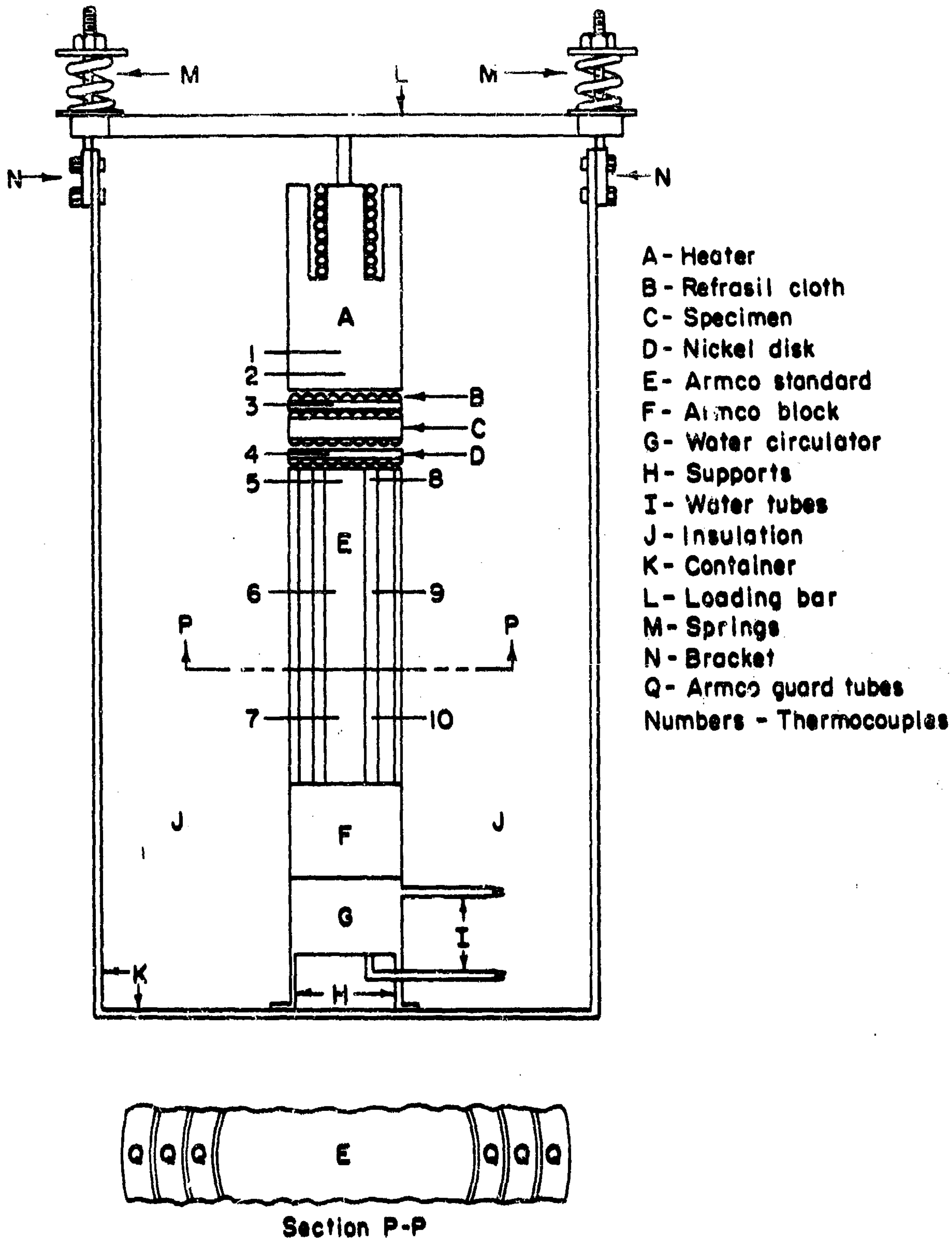

FIGURE 1. THERMAL-CONDUCTIVITY APPARATUS FOR TRANSPARENT SOLIDS

A-4643

Figure 1 shows one specimen between two nickel disks, each nickel disk containing a thermocouple. Actually, two specimens are measured at one time, by alternating specimens and nickel disks in the stack. Disks of Refrasil cloth (No. C-100-28) are placed between the nickel and the specimens, and also next to the heater and the Armco standard.

Specimen surface temperatures are obtained by an extrapolation of the temperature difference across the layer of cloth in contact with a specimen. This method of obtaining the specimen surface temperature requires that the thermal conductance of the cloth be known and that it be constant, except for temperature effects.

The data of Figure 3 of USAF Technical Report No. 6145-2 showed scatter which could be related to a variation in the conductance of successive layers of the cloth. Since the conductance of the cloth would be related to its "density", or compactness, under the load applied to it during the measurements, a study was made of the load-deformation characteristics of the cloth at room temperature. It was found that the change in deformation with load was much less for loads of more than about 100 pounds than for lower loads, and the cloth had some permanent set between successive loadings. As a result of these tests, a load of 161 pounds (the heater load of 11 pounds plus 150 pounds additional load, giving about 23 p.s.i. on the cloth and specimen) is used during the thermal-conductivity measurements. The spring loading arrangement is shown in Figure 1.

The extrapolation method of specimen temperature measurement depends mainly upon the uniformity of the cloths under all test conditions. An evaluation of this uniformity has been made by measuring the conductances of the glass cloths at temperature and pressure. The conductance, C, is defined as:

$$C = \frac{Q}{A\Delta T} ,$$

where

Q = heat flow
A = area
ΔT = temperature difference across the cloth.

Figure 2 shows the typical characteristics of conductance versus temperature of Refrasil cloth. The conductance of the cloth following a preload of 70 p.s.i. is linear up to about 700°C. Above 700°C. the conductance increases rapidly with pressure, temperature, and time. After a thermal-conductivity measurement above about 700°C. the clothes were thinner than when installed. The range in which the cloths are linear in conductance can be extended by pretreating the cloth at higher temperatures and pressures than would be encountered in the apparatus. This

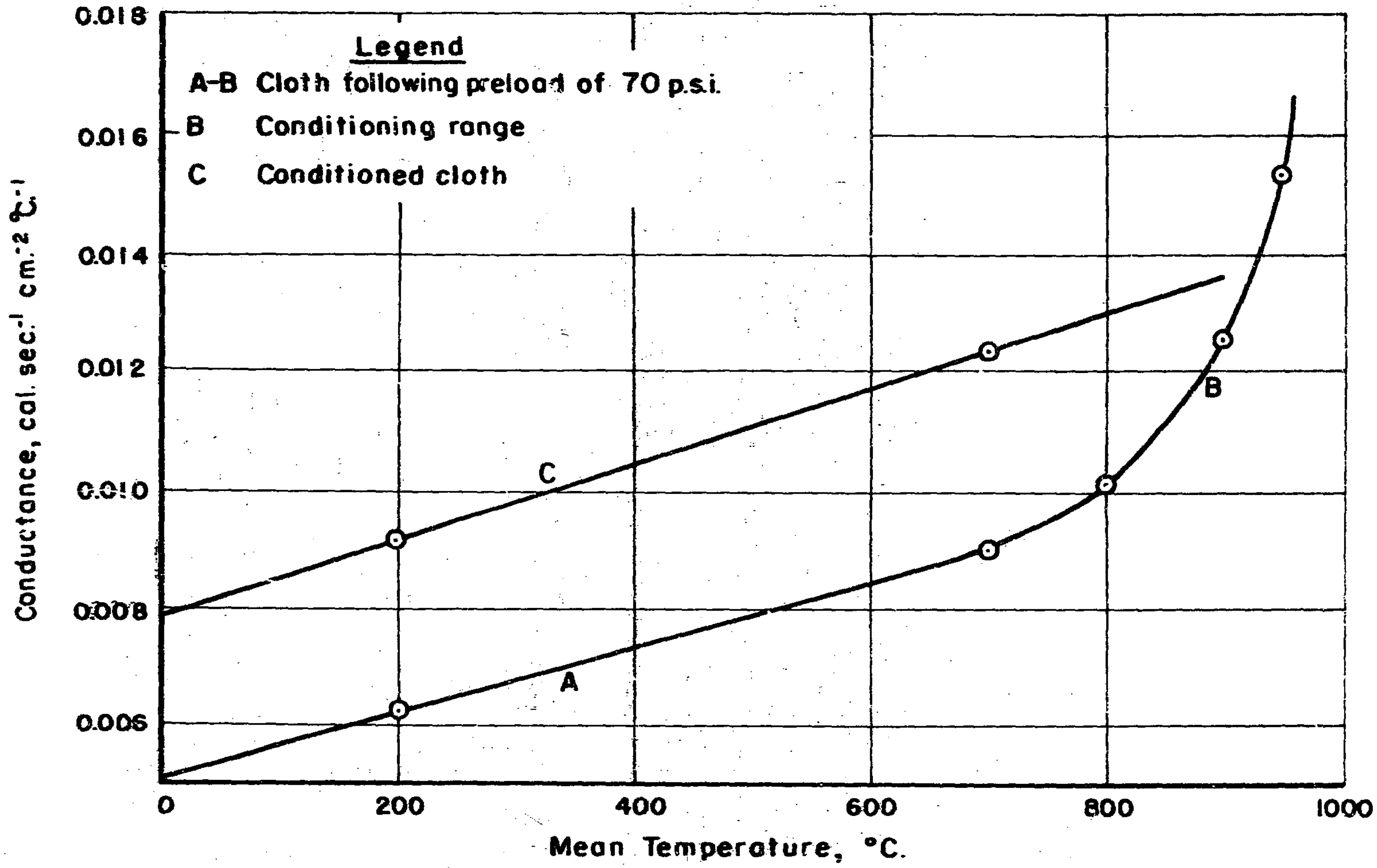

FIGURE 2. TEMPERATURE CHARACTERISTICS OF TYPICAL REFRASIL CLOTH

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conditioning process increased the reproducibility of thermal-conductivity measurements by making the cloths more uniform. The conditioning treatment used consists of subjecting the 3-inch-diameter Refrasil disks to a load of 250 pounds at 1000°C. for 4 hours.

Where indicated, 0.0025-inch-thick low-emissivity foil was used adjacent to the surface of the transparent solid specimens to minimize the transfer of heat by direct radiation through the specimens, if any, by the adjoining high-emissivity surfaces of the apparatus. Kellett[4] has presented a mathematical treatment of the radiant heat transfer through glass owing to high-emissivity surfaces in contact with the glass.

Results

Thermal-conductivity values for white (clear) plate glass are given in Table 2 and are plotted in Figure 3. The data with and without low-emissivity metal foil adjacent to the specimen surface were in good agreement. Interpolated values in the temperature range of 150 to 500°C. are given in Table 3.

Thermal-conductivity values for Solex 2808X plate glass are given in Table 4 and are plotted in Figure 4, and interpolated values from 150 to 500°C. are given in Table 3.

Thermal-conductivity values for Solex "S" plate glass are given in Table 5 and are plotted in Figure 5. Table 3 shows interpolated values over a temperature range of 150 to 500°C.

Thermal-conductivity values for Vycor glass are given in Table 6 and are plotted in Figure 6. Interpolated thermal-conductivity values for Vycor between 150 and 800°C. are shown in Table 3. Low-emissivity metal foil was not used in these particular measurements, and it is very likely that the increased slope of the curve in Figure 6 above about 450°C. is the result of heat transfer by direct radiation through the Vycor.

Thermal-conductivity values for clear fused silica (quartz) without low-emissivity metal foil adjacent to the specimen surface are given in Table 7 and are plotted in Figure 7. Table 8 gives the thermal-conductivity values of clear fused silica (quartz) with low-emissivity foil adjacent to the specimen surface. The values are also plotted in Figure 7. With radiation minimized by the use of low-emissivity metal foil adjacent to the specimen surface, the thermal conductivity was found to increase linearly with temperature. Without the metal foil present, the observed thermal conductivity increased more rapidly above about 450°C. Interpolated thermal-conductivity values both with and without metal foil adjacent to the specimen surface are given in Table 3 for the temperature range 150 to 800°C.

TABLE 2. OBSERVED THERMAL CONDUCTIVITY OF WHITE (CLEAR) PLATE GLASS

Temperature, °C.	Thermal Conductivity, cal. sec.$^{-1}$cm.$^{-2}$ cm. °C.$^{-1}$
146	0.0030_0
146	0.0028_9
147	0.0029_5
148	0.0027_3
151	0.0027_5
153	0.0027_2
153	0.0030_2*
166	0.0028_7
205	0.0030_3
223	0.0030_1
227	0.0031_4*
234	0.0029_4
236	0.0030_6
258	0.0032_3
259	0.0030_9
260	0.0030_9*
263	0.0030_6
296	0.0031_9
306	0.0032_1
349	0.0033_1
361	0.0034_3
393	0.0033_2
395	0.0034_5
427	0.0034_1
436	0.0034_5
445	0.0035_3
455	0.0035_1*
463	0.0037_7

*Aluminum foil 0.00025 inch thick adjacent to specimen surface.

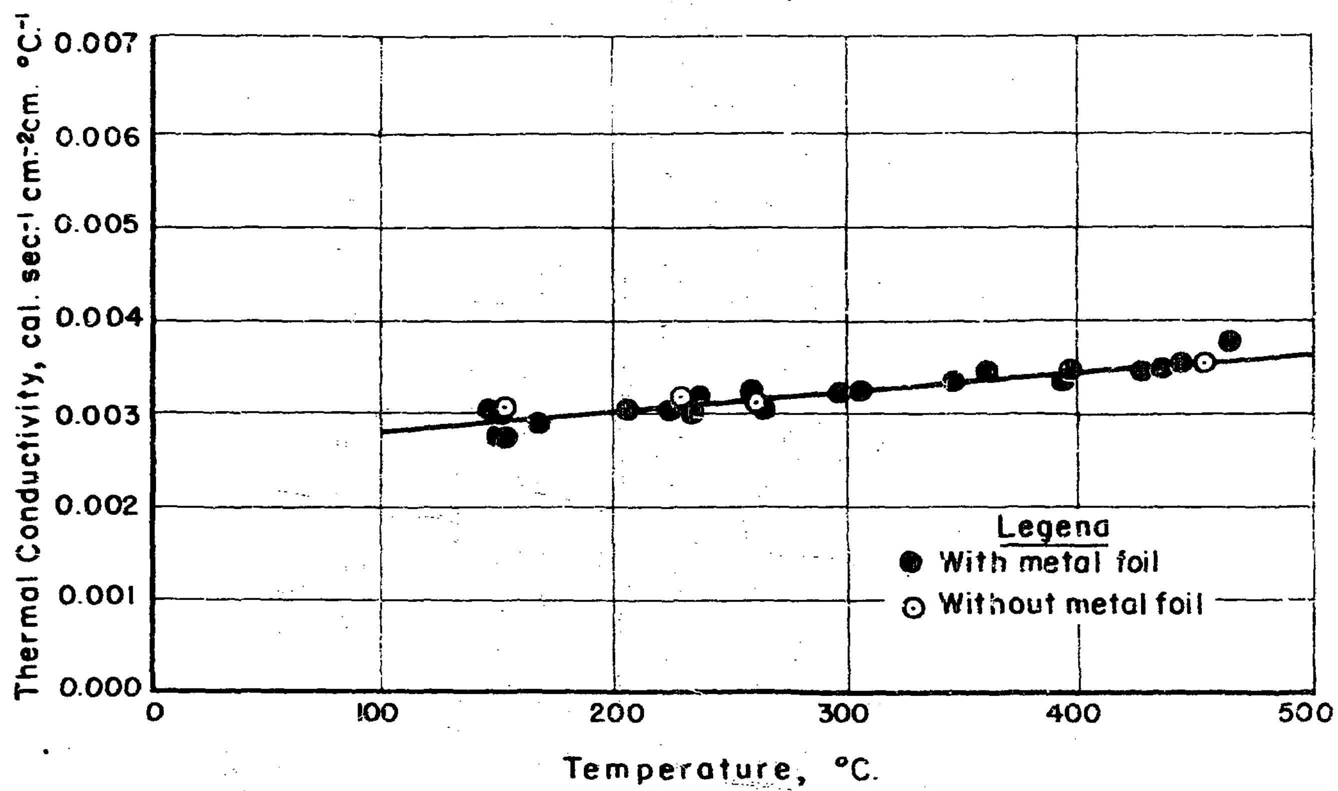

FIGURE 3. THERMAL CONDUCTIVITY VERSUS TEMPERATURE FOR WHITE (CLEAR) PLATE GLASS

A-9457

TABLE 3. INTERPOLATED VALUES OF THE THERMAL CONDUCTIVITIES OF FIVE GLASSES AT SELECTED TEMPERATURES

Glass	Thermal Conductivity, cal. sec.$^{-1}$cm.$^{-2}$ cm. °C.$^{-1}$						
	150°C.	200°C.	300°C.	400°C.	500°C.	700°C.	800°C.
White plate	0.0029	0.0030	0.0032	0.0034	0.0035		
Solex 2808X	0.0030	0.0030	0.0031	0.0031	0.0032		
Solex "S"	0.0029	0.0030	0.0032	0.0033	0.0034		
Vycor	0.0039	0.0040	0.0041	0.0042	0.0045	0.0057	0.0065
Clear fused silica (quartz) without low-emissivity foil adjacent to surface	0.0045	0.0046	0.0048	0.0051	0.0054	0.0069	0.0082
Clear fused silica (quartz) with low-emissivity foil adjacent to surface	0.0045	0.0046	0.0048	0.0051	0.0053	0.0057	0.0059

TABLE 4. OBSERVED THERMAL CONDUCTIVITY OF SOLEX 2808X PLATE GLASS

Temperature, °C.	Thermal Conductivity, cal. sec.$^{-1}$cm.$^{-2}$ cm. °C.$^{-1}$
140	0.0029_9
181	0.0030_1
213	0.0030_8
240	0.0029_3
254	0.0030_7
313	0.0030_3
371	0.0031_2
441	0.0031_9

TABLE 5. OBSERVED THERMAL CONDUCTIVITY OF SOLEX "S" PLATE GLASS

Temperature, °C.	Thermal Conductivity, cal. sec.$^{-1}$cm.$^{-2}$ cm. °C.$^{-1}$
148	0.0028_7
166	0.0029_5
209	0.0030_2
257	0.0030_3
262	0.0029_5
289	0.0031_8
366	0.0032_8
458	0.0034_1

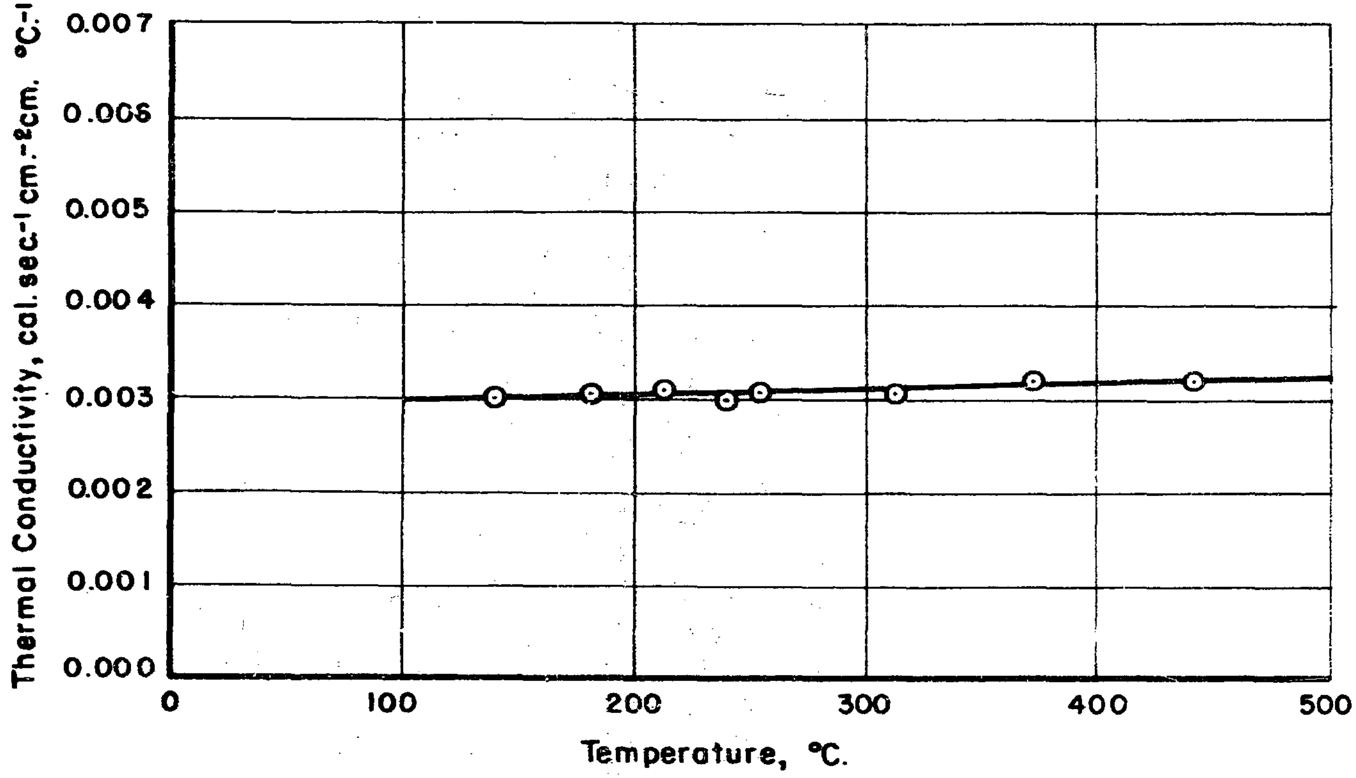

FIGURE 4. THERMAL CONDUCTIVITY VERSUS TEMPERATURE FOR SOLEX 2808X PLATE GLASS

A-9462

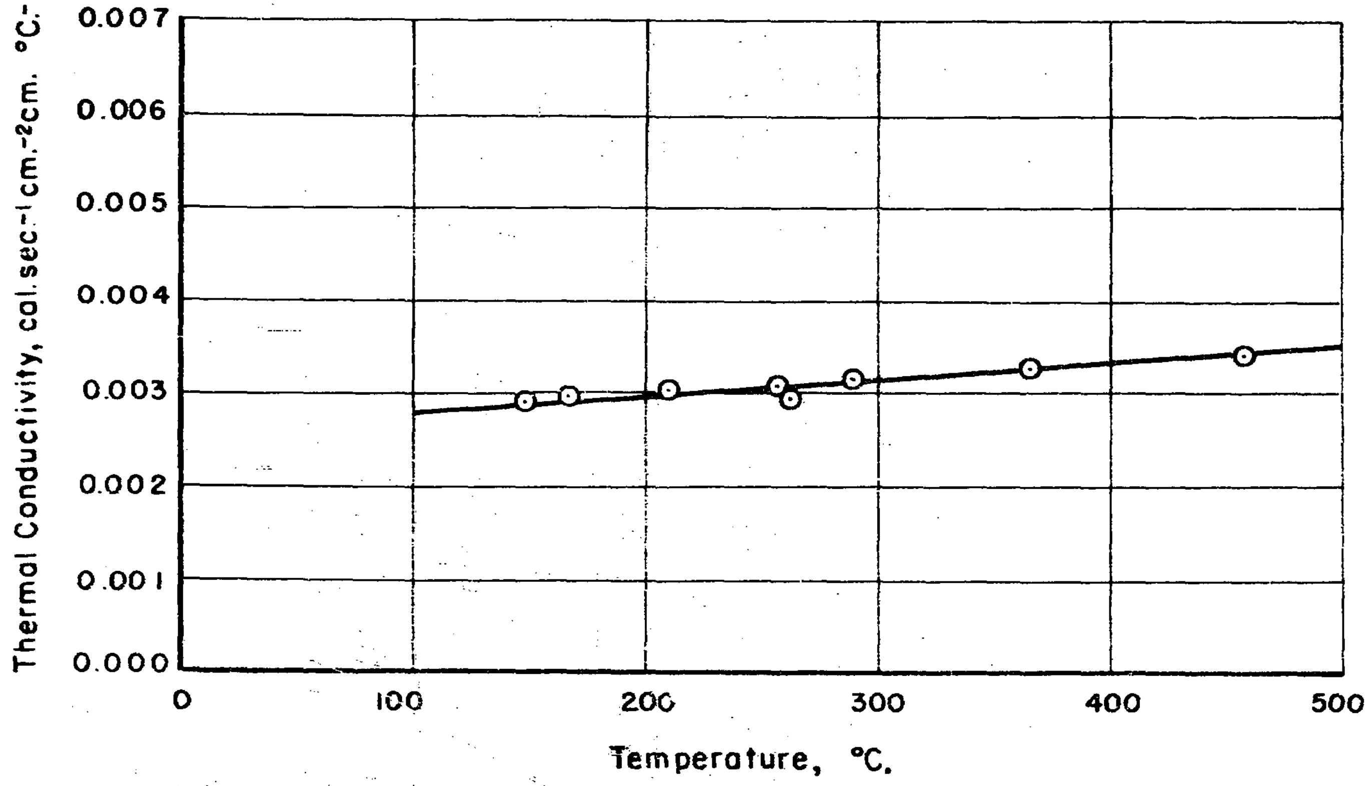

FIGURE 5. THERMAL CONDUCTIVITY VERSUS TEMPERATURE FOR SOLEX "S" PLATE GLASS

A-9463

TABLE 6. OBSERVED THERMAL CONDUCTIVITY OF VYCOR

Temperature, °C.	Thermal Conductivity, cal. sec.$^{-1}$ cm.$^{-2}$ cm. °C.$^{-1}$
169	0.0038_9
191	0.0038_7
218	0.0040_2
247	0.0040_6
278	0.0040_7
287	0.0040_7
309	0.0041_2
331	0.0041_4
360	0.0041_5
373	0.0041_5
410	0.0043_1
430	0.0042_6
466	0.0042_7
480	0.0044_4
502	0.0044_8
522	0.0045_7
560	0.0047_7
617	0.0052_8
675	0.0055_5
718	0.0057_4
786	0.0060_7

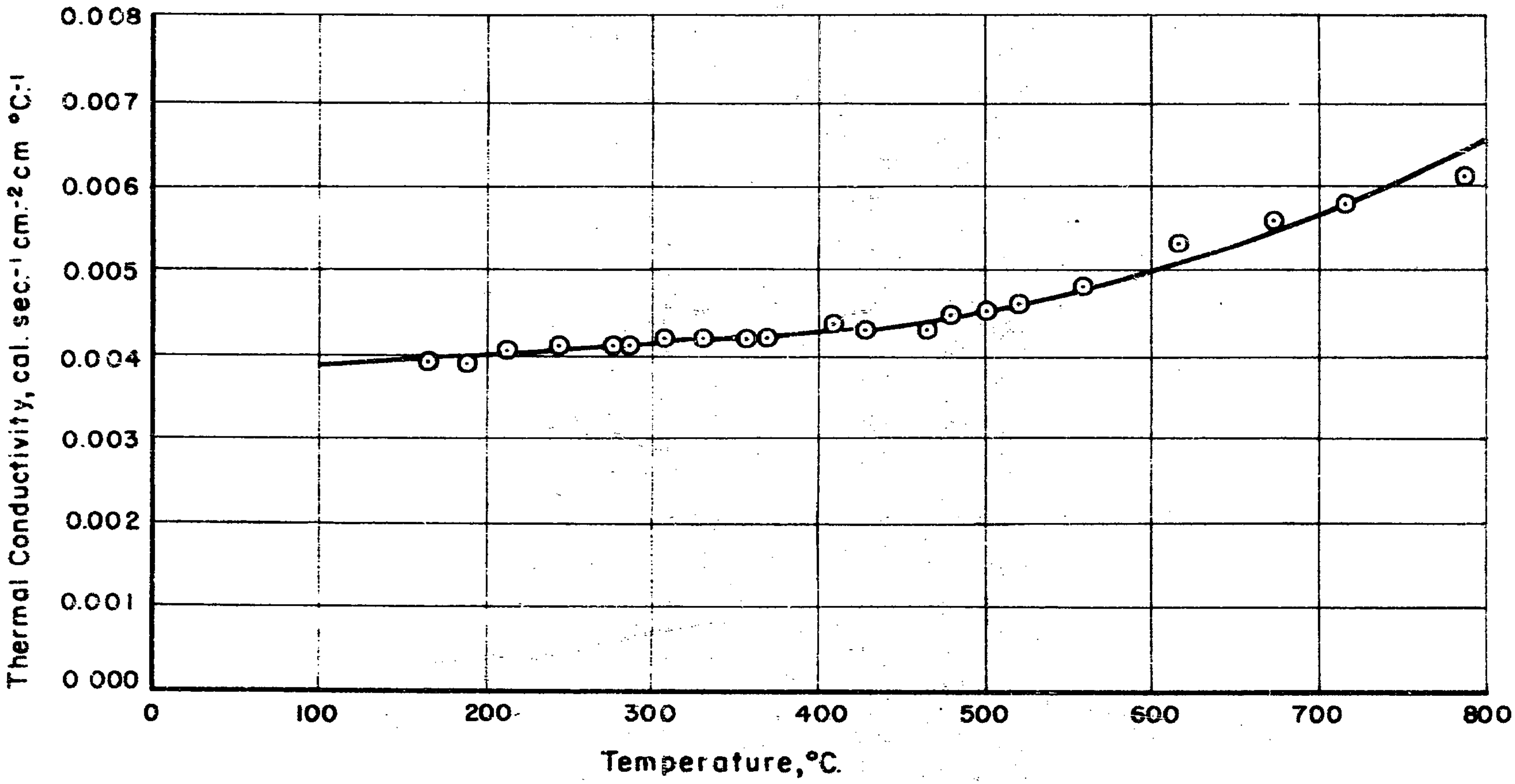

FIGURE 6. THERMAL CONDUCTIVITY VERSUS TEMPERATURE FOR VYCOR

A-9460

TABLE 7. OBSERVED THERMAL CONDUCTIVITY OF CLEAR FUSED SILICA (QUARTZ) WITHOUT LOW-EMISSIVITY FOIL ADJACENT TO SURFACE

Temperature, °C.	Thermal Conductivity, cal. sec.$^{-1}$cm.$^{-2}$ cm. °C.$^{-1}$
168	0.0043_7
229	0.0045_5
273	0.0047_6
281	0.0047_9
295	0.0047_9
315	0.0048_2
358	0.0049_9
381	0.0048_1
384	0.0051_1
386	0.0050_6
404	0.0051_1
406	0.0052_7
420	0.0049_0
441	0.0049_9
441	0.0052_2
455	0.0052_5
464	0.0050_1
492	0.0056_1
523	0.0056_7
591	0.0061_2
629	0.0061_7
634	0.0063_4
662	0.0065_5
665	0.0066_9
667	0.0067_5
686	0.0066_3
718	0.0070_8
718	0.0069_0
752	0.0073_7
764	0.0078_6

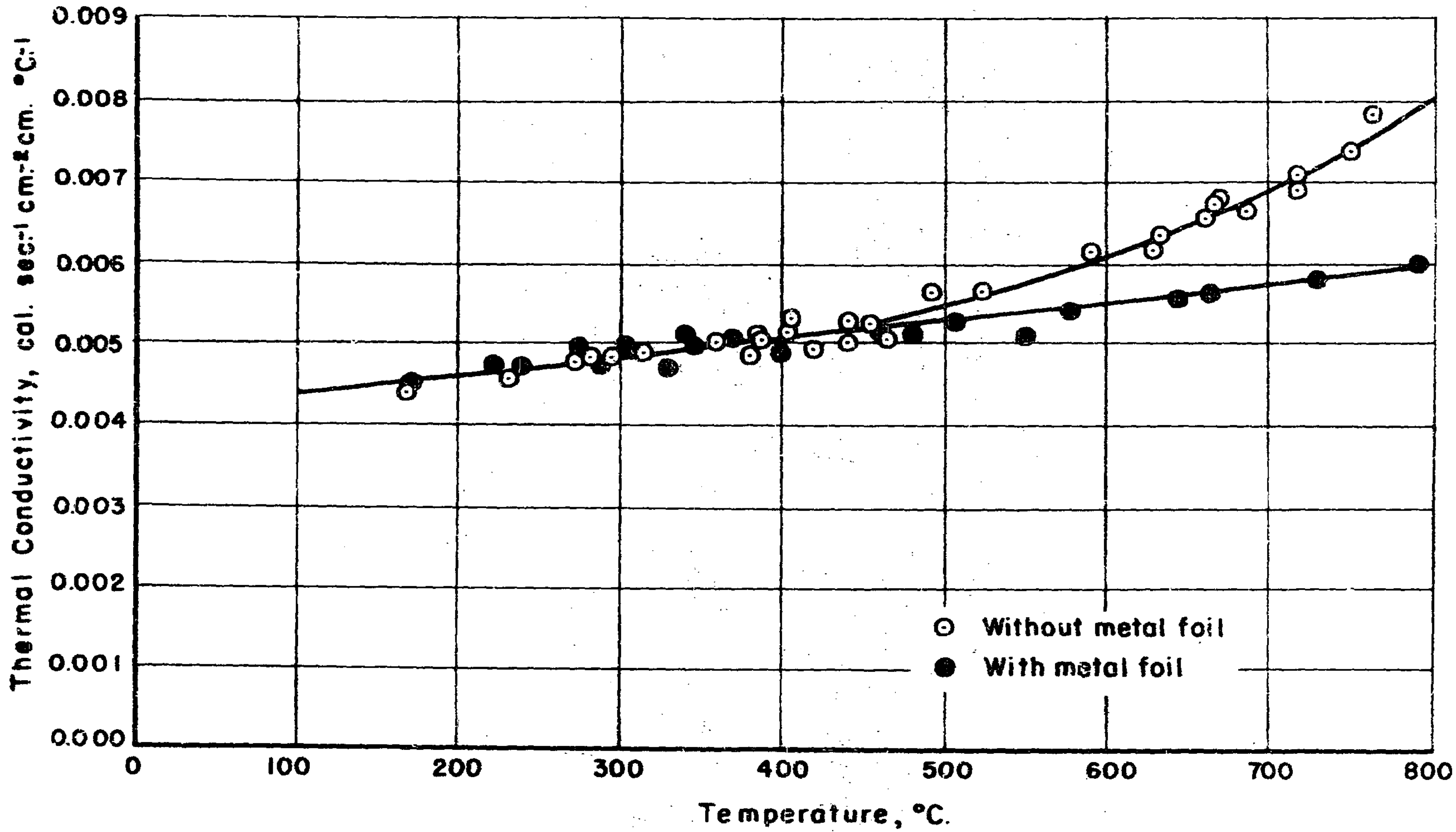

FIGURE 7. THERMAL CONDUCTIVITY VERSUS TEMPERATURE FOR CLEAR FUSED SILICA (QUARTZ)

A-9456

TABLE 8. OBSERVED THERMAL CONDUCTIVITY OF CLEAR FUSED SILICA (QUARTZ) WITH LOW-EMISSIVITY FOIL ADJACENT TO SURFACE

Temperature, °C.	Thermal Conductivity, cal. sec.$^{-1}$cm.$^{-2}$ cm. °C.$^{-1}$
172	0.0044_8
221	0.0047_1
238	0.0046_7
275	0.0049_2
287	0.0047_7
303	0.0049_3
329	0.0047_0
340	0.0050_8
346	0.0049_9
370	0.0050_3
387	0.0050_8
400	0.0048_8
441	0.0051_2
462	0.0051_7
481	0.0051_0
508	0.0052_6
552	0.0050_9
578	0.0054_0
644	0.0055_6
664	0.0056_7
730	0.0058_1
792	0.0060_1

Thermal-conductivity values reported in the literature for fused silica are given in Table 9, along with the observed values at corresponding temperatures.

SECTION III

SPECIFIC HEAT

Methods and Apparatus

The ice calorimeter and associated apparatus used in specific-heat determinations are described in detail in USAF Technical Reports Nos. 6145-1[1] and 6145-2[2]. A schematic diagram of the calorimeter is shown in Figure 8. In brief, the ice calorimeter measures the quantity of heat by the volume change when ice in equilibrium with water is melted or frozen. Volume changes are measured by measuring the mercury displaced from the calorimeter system. Schematic diagrams of the furnace and the coolant chamber are shown in Figures 9 and 10, respectively.

An improved second calorimeter well was assembled. In this well, the inner jar is larger and accommodates a slightly larger ice mantle. Silver solder was used for joints in the well tube and for the bottom closure. Also, the metal valve in the mercury accounting system was replaced with a vacuum-type stop cock.

The technique for filling the inner jar was modified so that a check can be made for leaks in the accounting system and calorimeter just before filling the jar with degassed distilled water and mercury. This is done by assembling the apparatus and evacuating the completed assembly through the capillary tubing of the mercury accounting system.

The formation of frost in the low-temperature apparatus prevented raising or lowering the specimen capsule properly and also caused ice particles to drop into the calorimeter well. This frosting was prevented by replacing the metal top-plate on the coolant chamber by one made of hardwood and by drying the helium gas which flowed into the calorimeter well and exited through the coolant tube. After these changes had been made, the calorimeter worked as well at low temperatures as at elevated temperatures.

As an accuracy check on the calorimeter, 28 enthalpy (total heat content per gram) measurements were made of aluminum oxide, Al_2O_3. These measurements were made at several temperatures. Ginnings and Corruccini[5] and Ginnings and Furukawa[6] have made extensive measurements of the enthalpy of Al_2O_3 and have shown this material to be well suited as a standard for the calibration of calorimeters. Table 10 lists the results of our enthalpy measurements on Al_2O_3 and compares them with the values obtained by Ginnings. Figure 11 shows our experimental points and the curve obtained by Ginnings.

TABLE 9. OBSERVED AND REPORTED THERMAL-CONDUCTIVITY VALUES FOR CLEAR FUSED SILICA (QUARTZ)

Temperature, °C.	Thermal Conductivity, cal. sec.$^{-1}$ cm.$^{-2}$ cm. °C.$^{-1}$				
	Observed	Reported Elsewhere			
150	0.0045	0.0030[1]	0.0052[2]	0.0035[3]	0.0043[4]
200	0.0046	0.0032[1]	0.0054[2]	0.0036[3]	0.0045[4]
300	0.0048	0.0034[1]			
338	0.0049	0.0060[4]			
400	0.0051	0.0036[1]			
500	0.0053	0.0039[1]			
600	0.0055	0.0041[1]			
700	0.0057	0.0044[1]			
800	0.0059	0.0048[1]			

(1) Jacob, Max, Heat Transfer, John Wiley and Sons, Inc., New York (1949), pp. 95-96 (data for "Soiled Quartz Glass").
(2) Loc. cit. (data for "Pure Quartz Glass").
(3) Kaye, G. W. C., and Higgens, W. F., "The Thermal Conductivity of Vitreous Silica, With a Note on Crystalline Quartz", Proc. Royal Soc., (London) A, 113, 335-351 (1926).
(4) Knapp, E. J., "Thermal Conductivity of Nonmetallic Single Crystals", J. Am. Ceram. Soc., 26, 48-55 (1943).

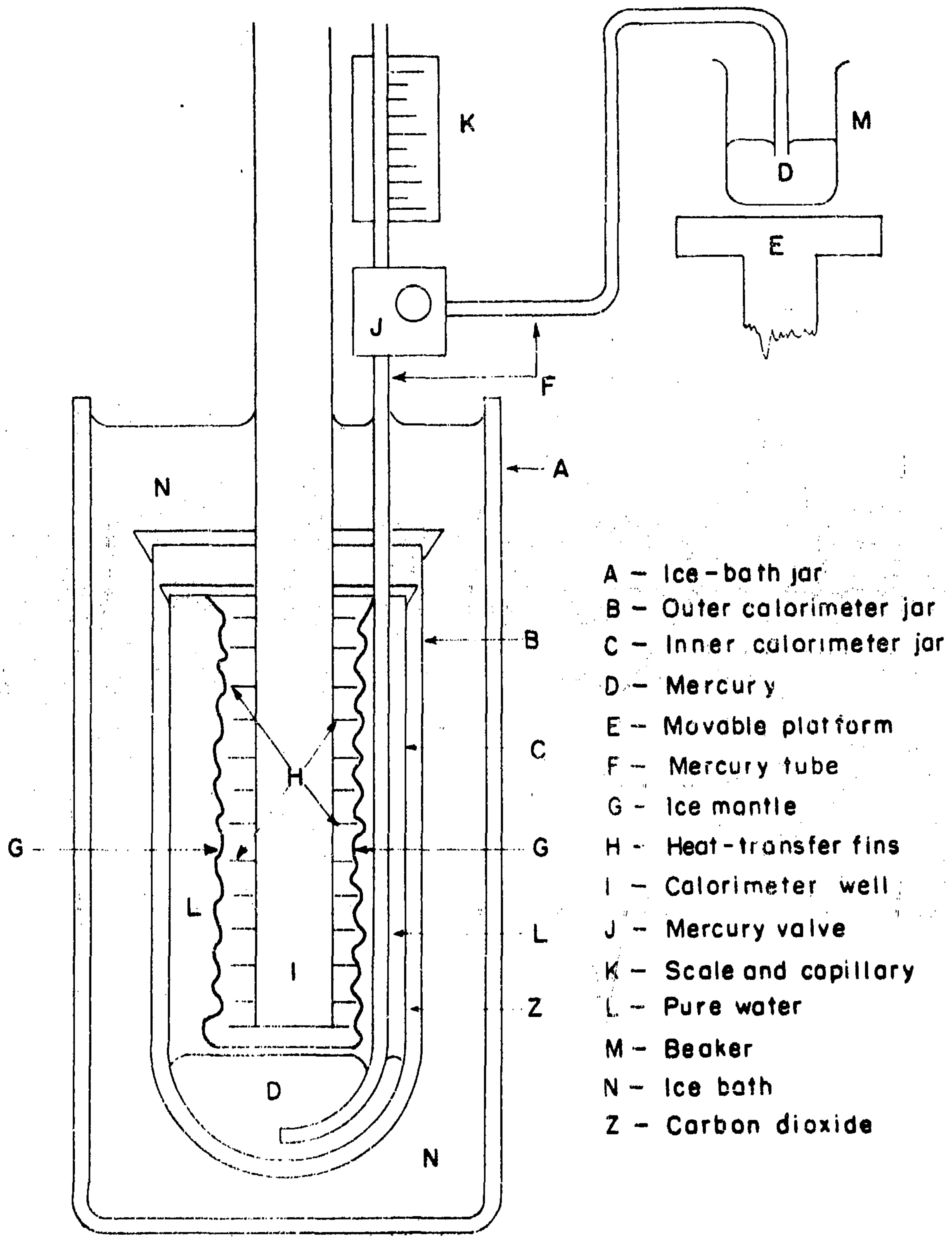

FIGURE 8. SCHEMATIC DIAGRAM OF ICE CALORIMETER

A-9461

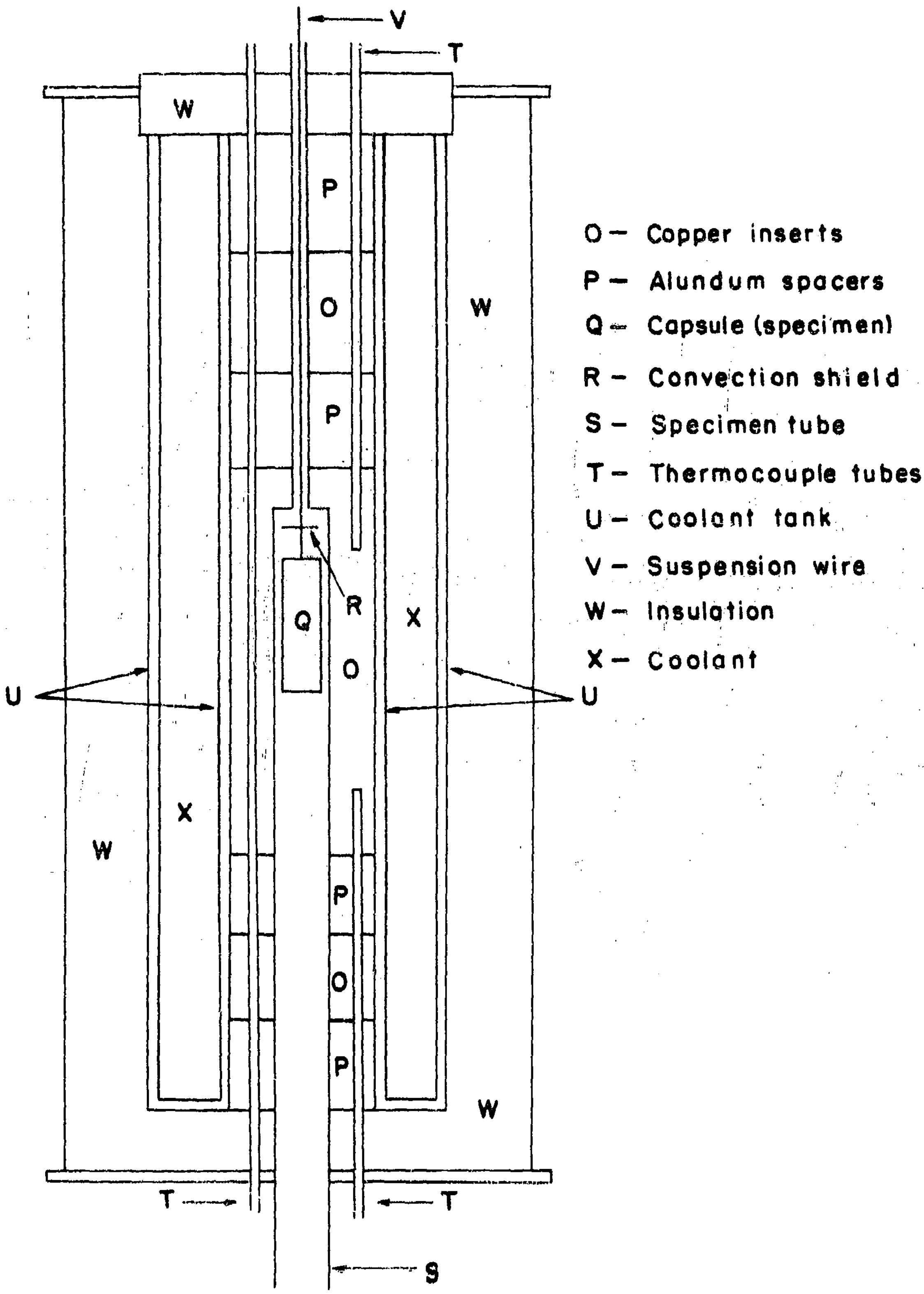

FIGURE 9. SCHEMATIC DIAGRAM OF COOLANT CHAMBER

A-9450

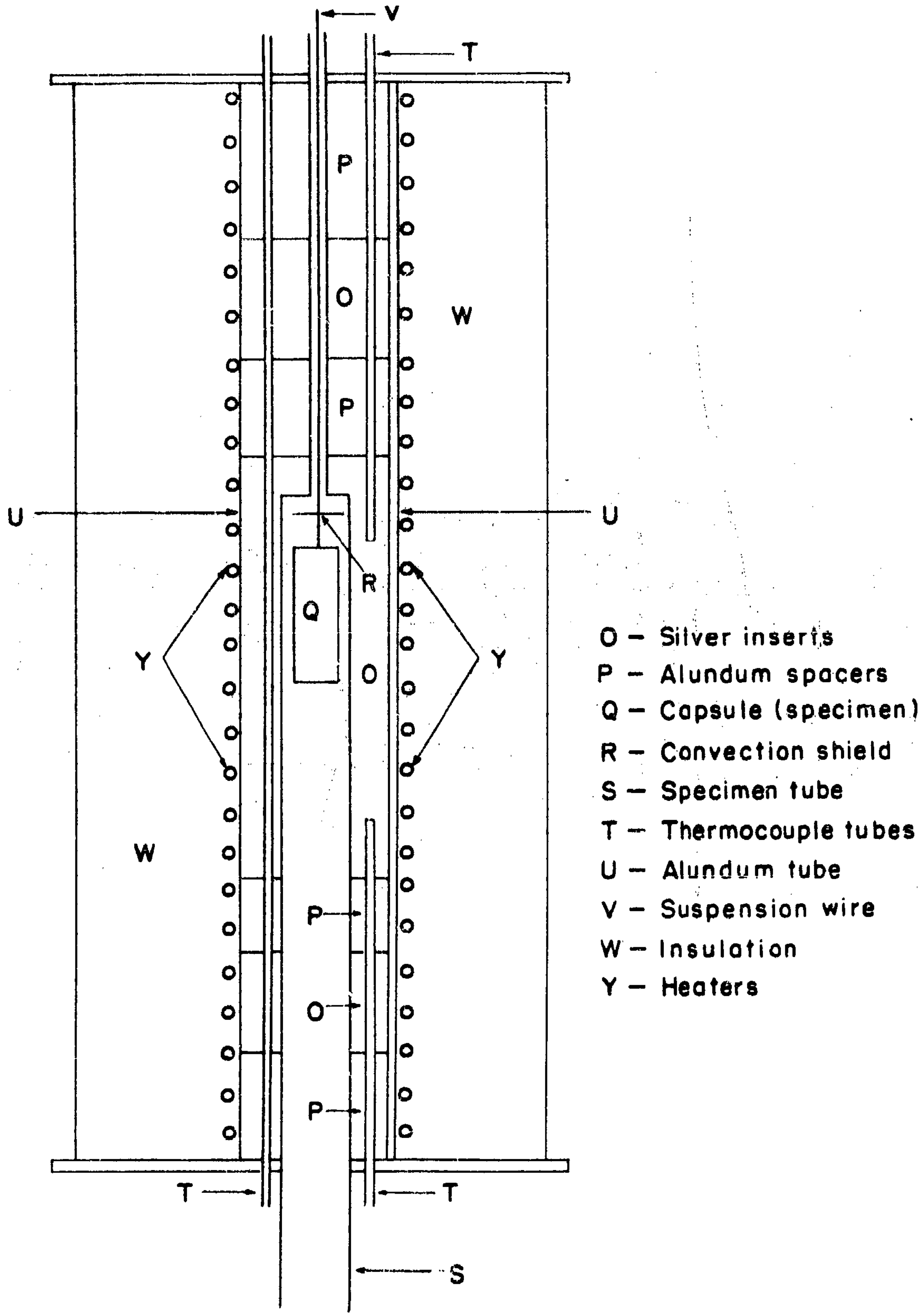

FIGURE 10. SCHEMATIC DIAGRAM OF FURNACE

A-9483

TABLE 10. ENTHALPY OF Al_2O_3 AT VARIOUS TEMPERATURES

Temperature, °C.	Enthalpy*, cal. $gram^{-1}$ Observed Value	Enthalpy*, cal. $gram^{-1}$ Calculated Value**	Per Cent Difference
-195.4	-18.77	-18.76	+0.05
- 78.2	-11.35	-11.35	0.00
- 78.3	-11.34	-11.35	-0.09
- 78.3	-11.39	-11.35	+0.30
94.6	18.30	18.32	-0.11
110.5	21.48	21.53	-0.20
206.7	44.00	44.05	-0.10
210.8	45.42	45.43	-0.02
239.7	52.50	52.59	-0.18
285.0	63.77	63.69	-0.12
285.6	64.10	64.29	-0.23
354.1	81.95	81.98	-0.04
355.2	82.85	82.80	+0.06
396.5	93.58	93.72	-0.15
433.1	103.61	103.70	-0.09
433.4	103.66	103.80	-0.14
443.3	106.22	106.52	-0.34
451.3	108.21	108.75	-0.40
535.0	131.80	131.89	-0.08
571.8	142.74	142.59	+0.10
573.4	143.15	143.04	+0.07
601.6	151.40	151.10	+0.19
628.0	158.97	158.69	+0.20
628.9	158.48	158.95	-0.30
633.8	160.39	160.36	+0.02
635.9	161.27	161.44	-0.11
785.1	203.83	204.25	-0.20
788.5	205.93	205.50	+0.11

* Enthalpy is the total heat content between the specified temperature and 0° C.

** Ginnings, D. C., and Corruccini, R. J., "Enthalpy, Specific Heat, and Entropy of Aluminum Oxide From 0 to 900° C.", Natl. Bur. Standards (U.S.), J. Research, 38, 593-600 (1947).
Ginnings, D. C., and Furukawa, G. T., "Heat Capacity Standards for the Range 14 to 1200° K.", J. Am. Chem. Soc., 75, 522 (1953).

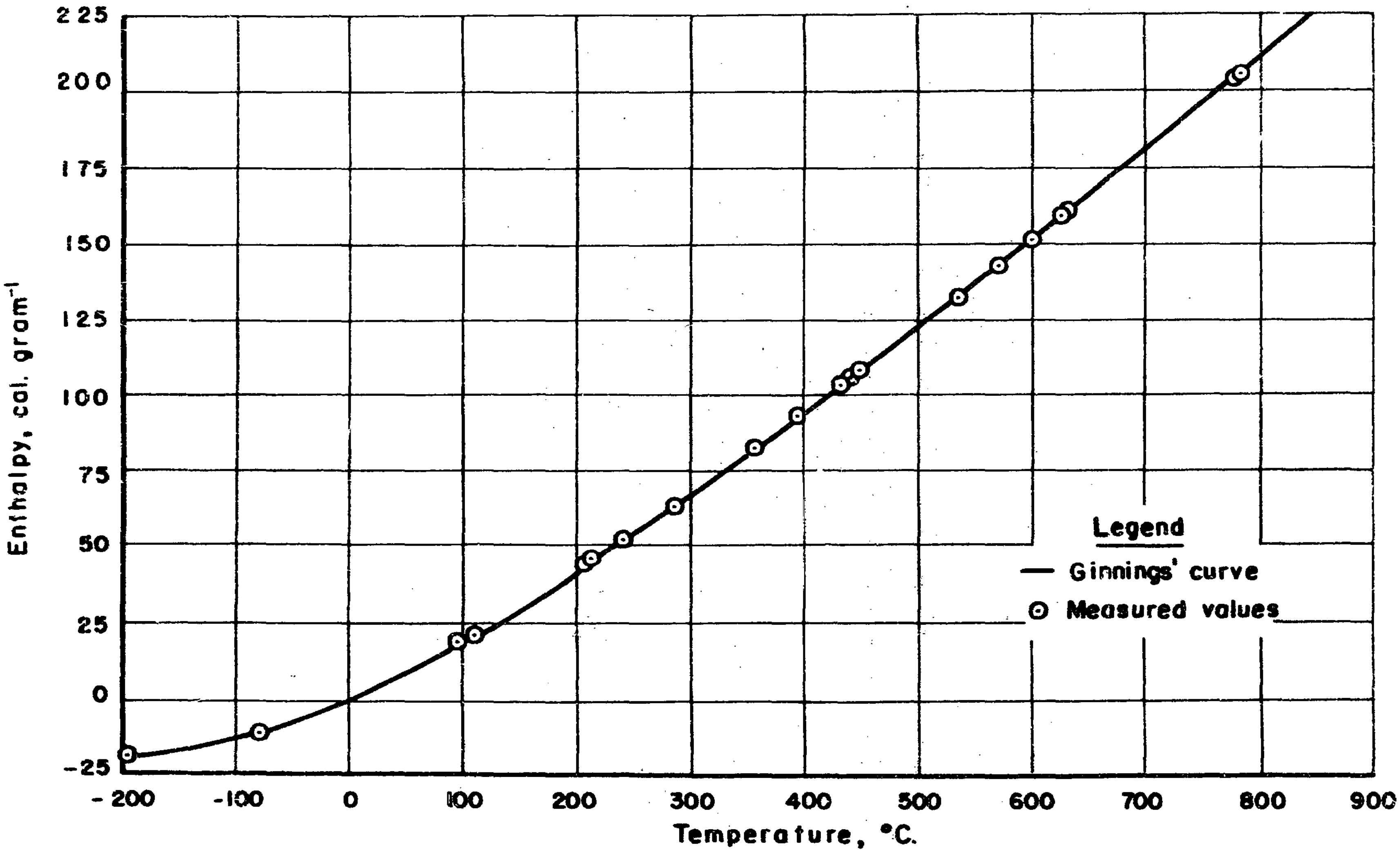

FIGURE 11. ENTHALPY VERSUS TEMPERATURE OF AL_2O_3

A-9446

Measurements of the enthalpies of ten metals and of seven transparent solids have been completed for both low and elevated temperatures.

Results

Measured values of enthalpy, H_o^t (the total heat content per gram between the specified temperature and 0 °C.), are given in the tables listed below for ten metals and seven transparent solids. Also shown in the tables are values of $\frac{H_o^t}{t}$, the average specific heat between the stated temperature and 0 °C. The materials and the corresponding table numbers are:

K-Monel	Table 11
Inconel	Table 12
Inconel X	Table 13
Stainless steel Type 301	Table 14
Stainless steel Type 316	Table 15
Stainless steel Type 347	Table 16
SAE 1010 mild steel	Table 17
Magnesium alloy Type AN-M-29	Table 18
Aluminum alloy Type 24S-T4	Table 19
Aluminum alloy Type 75S-T6	Table 20
Clear fused silica (quartz)	Table 21
Vycor	Table 22
White (clear) plate glass	Table 23
Pyrex, clear chemical glass No. 774	Table 24
Solex "S" plate glass	Table 25
Solex 2808X plate glass	Table 26
Plexiglass Type AN-P-44A	Table 27

Least-squares calculations were made to get the enthalpy as a function of temperature. The general form of the enthalpy equation used was:

$$H_o^t = At + Bt^2 + Ct^3 + Dt^4.$$

To derive the specific heat from the enthalpy, the following equation is used:

$$C_p = \left(\frac{\partial H_o^t}{\partial t}\right)_p$$

Differentiating the enthalpy expression with respect to temperature gave the specific-heat equation:

$$C_p = A + 2Bt + 3Ct^2 + 4Dt^3.$$

TABLE 11. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF K-MONEL AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.6	-16.03	0.0820
-195.6	-16.02	0.0819
- 78.4	- 7.28	0.0930
- 78.4	- 7.25	0.0924
- 78.3	- 7.28	0.0929
25.3	2.55	0.1009
25.8	2.68	0.1040
139.4*	14.87	0.1067
140.4*	14.91	0.1062
267.4*	29.60	0.1107
354.7*	39.17	0.1104
355.5*	39.16	0.1102
359.5*	39.72	0.1105
485.1*	54.70	0.1114
585.4*	68.15	0.1164
590.9*	68.55	0.1160
682.8*	80.20	0.1175
690.9*	80.90	0.1171
800.6*	97.20	0.1214
799.9*	96.97	0.1212
857.4*	104.85	0.1221

*Values reported in USAF Technical Report No. 6145-2, July, 1952.

TABLE 12. MEASURED VALUES OF THE ENTHALPY, H_0^t, OF INCONEL AND VALUES OF H_0^t/t

Temperature, °C.	Enthalpy, H_0^t, cal. gram^{-1}	$\frac{H_0^t}{t}$
-195.3	- 16.32	0.0836
-195.3	- 16.31	0.0835
- 78.4	- 7.37	0.0940
- 78.4	- 7.37	0.0940
19.0	2.02	0.1063
19.4	2.03	0.1050
136.9*	14.72	0.1078
139.8*	15.20	0.1089
271.2*	30.66	0.1130
273.1*	30.83	0.1136
392.8*	45.21	0.1150
396.1*	45.81	0.1157
397.9*	45.58	0.1142
480.0*	56.20	0.1169
480.6*	56.41	0.1171
596.3*	71.60	0.1200
599.6*	71.68	0.1201
600.2*	72.30	0.1202
696.7*	86.62	0.1242
698.2*	85.31	0.1221
706.1*	86.69	0.1226
707.2*	87.60	0.1239
804.0*	100.01	0.1244
811.6*	103.19	0.1270
814.4*	103.17	0.1269
857.4*	109.36	0.1277
859.8*	109.98	0.1280
863.6*	109.81	0.1272

*Values reported in USAF Technical Report No. 6145-2, July, 1952.

TABLE 13. MEASURED VALUES OF THE ENTHALPY, H_0^t, OF INCONEL X AND VALUES OF H_0^t/t

Temperature, °C.	Enthalpy, H_0^t, cal. gram^{-1}	$\frac{H_0^t}{t}$
-195.3	- 16.48	0.0844
-195.3	- 16.42	0.0841
- 78.4	- 7.41	0.0947
- 78.4	- 7.41	0.0947
- 78.3	- 7.40	0.0946
25.6	2.85	0.1016
26.0	2.76	0.1038
155.0	16.78	0.1082
156.4	16.86	0.1077
158.3	17.02	0.1075
261.4	29.07	0.1112
264.9	29.45	0.1112
267.0	29.80	0.1116
362.4	41.28	0.1139
362.7	41.52	0.1144
365.1	41.58	0.1139
448.5	52.01	0.1160
450.5	52.12	0.1157
452.1	52.40	0.1159
539.8	63.65	0.1179
543.0	63.65	0.1172
545.5	64.11	0.1175
635.1	75.77	0.1193
636.3	76.07	0.1195
739.8	91.21	0.1233
742.4	92.10	0.1241
852.1	108.35	0.1271
853.2	108.53	0.1272

TABLE 14. MEASURED VALUES OF THE ENTHALPY, H_0^t, OF STAINLESS STEEL TYPE 301 AND VALUES OF H_0^t/t

Temperature, °C.	Enthalpy, H_0^t, cal. gram^{-1}	$\frac{H_0^t}{t}$
-195.5	- 17.62	0.0901
-195.3	- 17.59	0.0900
- 78.5	- 8.05	0.1026
- 78.5	- 8.00	0.1019
- 78.4	- 8.01	0.1020
25.4	2.97	0.1120
25.9	2.97	0.1147
152.5	17.81	0.1168
154.6	17.96	0.1162
269.0	32.37	0.1203
271.6	32.87	0.1210
418.8	52.44	0.1252
421.3	52.62	0.1249
423.3	52.62	0.1243
522.0	66.87	0.1282
523.4	67.27	0.1285
524.8	67.66	0.1289
636.0	82.66	0.1300
639.5	83.42	0.1304
740.3	97.90	0.1322
741.3	98.47	0.1328
863.7	116.31	0.1347
866.0	116.92	0.1350

TABLE 15. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF STAINLESS STEEL TYPE 316 AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.5	- 17.35	0.0888
-195.2	- 17.26	0.0884
- 78.4	- 7.98	0.1018
- 78.4	- 7.96	0.1015
- 78.4	- 7.95	0.1014
25.5	2.94	0.1056
25.9	2.91	0.1022
140.2	15.50	0.1105
144.5	16.66	0.1153
303.0	36.51	0.1205
305.0	37.03	0.1214
425.1	52.44	0.1233
432.0	53.33	0.1235
526.8	66.00	0.1253
534.0	67.34	0.1261
633.3	81.01	0.1279
639.4	81.89	0.1281
745.2	97.42	0.1307
749.7	98.12	0.1309
849.4	112.49	0.1324
854.6	113.01	0.1322

TABLE 16. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF STAINLESS STEEL TYPE 347 AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.7	- 17.40	0.0890
-195.6	- 17.37	0.0888
- 79.1	- 7.99	0.1013
- 78.8	- 7.95	0.1011
25.6	2.89	0.1130
26.0	2.96	0.1139
145.8	16.83	0.1155
145.9	16.77	0.1150
298.2	35.68	0.1196
300.7	36.00	0.1197
416.0	50.60	0.1217
419.8	51.38	0.1224
526.9	65.62	0.1246
528.0	66.57	0.1262
634.5	81.41	0.1283
636.5	81.63	0.1282
740.7	97.00	0.1309
742.6	97.81	0.1317
842.5	112.03	0.1330
845.5	112.55	0.1331

TABLE 17. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF SAE 1010 MILD STEEL AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.5	- 15.83	0.0810
-195.4	- 15.84	0.0810
- 78.3	- 7.46	0.0954
- 78.3	- 7.47	0.0954
- 78.3	- 7.50	0.0958
17.8	1.98	0.1011
18.4	2.02	0.1012
149.6	16.40	0.1099
154.0	17.10	0.1110
165.9	18.73	0.1129
169.5	19.04	0.1123
252.2	29.33	0.1163
255.4	29.87	0.1175
295.3	35.70	0.1207
296.6	35.80	0.1209
369.7	45.86	0.1240
371.6	46.08	0.1240
436.8	55.40	0.1269
441.0	56.20	0.1274
494.0	64.22	0.1300
497.1	64.44	0.1297
499.9	64.58	0.1292
530.0	69.80	0.1317
530.9	69.70	0.1313
611.5	84.22	0.1378
616.1	85.32	0.1385
633.4	87.90	0.1389
643.8	89.90	0.1397
702.0	100.48	0.1431
704.5	101.13	0.1436
724.7	105.99	0.1463
726.1	106.25	0.1464
741.3	111.60	0.1504
745.5	112.20	0.1505
748.9	114.09	0.1523
752.2	115.97	0.1542
753.0	116.53	0.1548
757.5	118.75	0.1568

TABLE 17. (Continued)

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
760.0	120.12	0.1581
761.7	120.90	0.1587
765.1	121.49	0.1588
766.4	121.51	0.1585
769.4	121.68	0.1590
772.5	122.02	0.1580
773.8	122.52	0.1583
775.8	122.63	0.1581
790.1	126.09	0.1596
812.8	130.87	0.1610
816.8	131.50	0.1611
818.7	131.58	0.1607
823.3	132.91	0.1614
830.4	134.72	0.1622
832.1	135.25	0.1625
836.1	135.39	0.1619
847.5	138.61	0.1635
854.8	140.79	0.1647
855.9	141.13	0.1657
856.0	141.10	0.1648
858.2	142.11	0.1656
864.7	143.55	0.1660
865.1	145.65	0.1684

TABLE 18. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF MAGNESIUM ALLOY TYPE AN-M-29 AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.7	- 39.13	0.2000
-195.5	- 39.12	0.2001
- 78.4	- 16.56	0.2106
- 78.4	- 16.51	0.2112
16.4	3.56	0.2178
17.1	3.65	0.2138
110.5	26.39	0.2388
110.5	26.43	0.2392
110.5	26.69	0.2415
160.6	39.26	0.2444
163.0	39.96	0.2452
204.6	50.60	0.2474
205.3	51.09	0.2489
205.6	51.55	0.2508
262.1	65.86	0.2513
262.8	66.60	0.2534
263.1	66.70	0.2534
304.6	77.30	0.2538
366.9	95.06	0.2597
368.1	95.55	0.2596
369.6	95.41	0.2581

TABLE 19. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF ALUMINUM ALLOY TYPE 24S-T4 AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.6*	- 31.92	0.1635
-195.6*	- 31.86	0.1633
-195.3	- 31.72	0.1624
-195.2	- 31.68	0.1623
- 78.4	- 14.69	0.1875
- 78.4	- 14.64	0.1867
- 78.3*	- 14.90	0.1905
- 78.3*	- 14.85	0.1898
- 78.2*	- 14.89	0.1904
24.9	4.79	0.1923
25.1	4.80	0.1911
26.1	4.96	0.1906
26.1	5.11	0.1929
26.2	5.05	0.1926
26.9*	5.36	0.1952
27.1*	5.31	0.1959
70.0	14.06	0.2028
70.0*	14.21	0.2029
70.1*	14.11	0.2013
70.1	14.29	0.2039
70.4	14.31	0.2032
92.8	19.33	0.2083
93.9	19.65	0.2093
110.5	23.02	0.2083
110.8	23.20	0.2093
111.2	23.29	0.2094
116.5*	24.45	0.2098
120.9*	25.58	0.2115
123.9*	25.90	0.2091
124.0*	25.96	0.2096
130.1	27.56	0.2118
133.9*	28.25	0.2111
135.8	28.96	0.2133
149.6	31.97	0.2136
150.8	32.20	0.2136
164.4	35.13	0.2138

TABLE 19. (Continued)

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
170.2	36.58	0.2149
174.8	37.71	0.2157
187.1	40.30	0.2161
190.0*	41.03	0.2159
205.3	44.70	0.2178
208.1	45.46	0.2184
263.1	57.99	0.2204
263.1	58.21	0.2212
360.7	81.83	0.2269
362.8	82.61	0.2277
463.9	109.53	0.2362
466.0	110.14	0.2364

*Specimen heated over 300°C.

TABLE 20. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF ALUMINUM ALLOY TYPE 75S-T6 AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.6	- 31.76	0.1624
-195.4*	- 31.68	0.1621
-195.4*	- 31.67	0.1620
-195.3	- 31.72	0.1621
- 78.4	- 14.56	0.1858
- 78.4	- 14.54	0.1855
- 78.3*	- 14.47	0.1850
- 78.3*	- 14.46	0.1849
- 78.3*	- 14.45	0.1847
- 78.3*	- 14.44	0.1845
25.1	4.84	0.1932
25.2	4.85	0.1924
25.4	4.87	0.1918
26.5*	5.13	0.1935
26.9*	5.37	0.1935
68.8	13.69	0.1993
68.8	13.86	0.2016
69.1	13.91	0.2014
70.2*	14.03	0.1999
70.2*	14.04	0.2001
92.1	18.84	0.2045
92.3	19.05	0.2064
95.3*	19.69	0.2066
106.0*	22.28	0.2102
111.9	23.15	0.2069
114.6	23.69	0.2067
119.1*	25.17	0.2114
121.1	25.27	0.2087
122.0	25.51	0.2091
125.3	26.19	0.2090
148.4	31.30	0.2110
148.6	31.48	0.2118
149.1	31.54	0.2115
162.1	34.71	0.2141
162.9	34.81	0.2137
186.8*	39.58	0.2159

TABLE 20. (Continued)

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
197.8	42.90	0.2169
201.8	43.66	0.2164
263.3	57.57	0.2186
264.7	58.16	0.2198
356.3	81.06	0.2275
358.2	82.07	0.2291
461.7	110.08	0.2384
462.8	110.33	0.2384

*Specimen heated over 275°C.

TABLE 21. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF CLEAR FUSED SILICA (QUARTZ) AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.4	- 21.87	0.1119
-195.3	- 21.74	0.1113
- 78.4	- 10.50	0.1340
- 78.4	- 10.21	0.1333
25.9	4.19	0.1620
25.9	4.20	0.1621
133.7	24.87	0.1860
134.6	25.02	0.1858
283.5	58.87	0.2077
284.2	59.28	0.2086
308.1	65.03	0.2111
399.5	89.02	0.2234
401.4	89.34	0.2226
425.9	94.76	0.2225
533.8	123.45	0.2313
535.0	123.71	0.2312
607.3	143.95	0.2371
607.5	144.05	0.2371
712.2	173.71	0.2439
713.3	174.12	0.2441
792.0	196.76	0.2484
793.6	197.71	0.2491

TABLE 22. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF VYCOR AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.4	- 22.36	0.1147
-195.4	- 22.36	0.1147
- 78.6	- 10.91	0.1387
- 78.6	- 10.91	0.1387
25.9	4.00	0.1544
25.9	4.01	0.1548
132.7	24.03	0.1811
136.0	24.44	0.1797
195.4	38.47	0.1969
195.7	38.51	0.1968
310.8	65.81	0.2118
311.8	66.19	0.2123
424.9	95.13	0.2239
425.3	95.48	0.2245
516.4	119.18	0.2308
516.7	119.19	0.2307
608.9	141.92	0.2331
610.0	142.25	0.2332
714.9	173.60	0.2428
717.4	174.20	0.2428
792.5	198.63	0.2507
799.7	202.50	0.2530
800.9	202.77	0.2532

TABLE 23. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF WHITE (CLEAR) PLATE GLASS AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.3	- 25.18	0.1290
-195.3	- 25.11	0.1286
- 78.6	- 12.36	0.1573
- 78.6	- 12.35	0.1571
26.1	4.53	0.1737
26.2	4.55	0.1738
126.9	24.42	0.1924
129.6	25.24	0.1947
195.3	40.72	0.2086
195.3	40.75	0.2087
309.3	68.62	0.2219
310.0	68.80	0.2219
424.2	98.95	0.2332
424.5	98.97	0.2331
517.1	123.62	0.2391
518.8	123.86	0.2392

TABLE 24. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF PYREX TYPE 774 AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.5	- 22.97	0.1175
-195.3	- 22.93	0.1174
- 78.4	- 10.87	0.1387
- 78.4	- 10.85	0.1385
25.7	4.28	0.1663
26.1	4.35	0.1665
101.8	18.51	0.1814
101.8	18.51	0.1814
207.3	42.50	0.2050
210.6	43.21	0.2053
303.4	66.49	0.2191
303.9	66.46	0.2188
413.0	96.52	0.2337
415.1	96.99	0.2336
536.6	130.27	0.2428
537.5	130.44	0.2427

TABLE 25. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF SOLEX "S" PLATE GLASS AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.4	- 24.82	0.1271
-195.3	- 24.79	0.1270
- 78.6	- 12.37	0.1574
- 78.6	- 12.35	0.1571
25.9	4.60	0.1774
26.0	4.60	0.1772
123.8	23.94	0.1934
125.3	24.21	0.1932
195.3	40.47	0.2072
195.7	40.40	0.2065
308.9	67.93	0.2199
309.5	68.09	0.2200
423.4	98.32	0.2322
423.9	98.63	0.2327
518.4	123.34	0.2379
519.4	123.64	0.2380

TABLE 26. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF SOLEX 2808X PLATE GLASS AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.3	- 25.45	0.1303
-195.2	- 25.46	0.1305
- 78.5	- 12.33	0.1571
- 78.5	- 12.31	0.1568
26.0	4.29	0.1652
26.0	4.30	0.1652
121.8	23.57	0.1935
122.7	23.67	0.1930
195.5	40.42	0.2068
196.1	40.57	0.2069
308.4	67.94	0.2203
308.7	68.08	0.2205
423.0	98.21	0.2322
423.3	98.48	0.2326
520.7	123.75	0.2376
522.6	124.07	0.2375

TABLE 27. MEASURED VALUES OF THE ENTHALPY, H_o^t, OF PLEXIGLASS TYPE AN-P-44A AND VALUES OF H_o^t/t

Temperature, °C.	Enthalpy, H_o^t, cal. gram^{-1}	$\frac{H_o^t}{t}$
-195.3	- 41.75	0.2138
-195.2	- 41.69	0.2137
- 78.5	- 20.40	0.2599
- 78.5	- 20.34	0.2590
24.7	7.03	0.2841
24.9	7.55	0.2898
57.0	18.46	0.3236
59.2	18.57	0.3135
72.1	23.65	0.3281
74.6	24.33	0.3261
98.0	33.23	0.3391
98.9	34.36	0.3476

The data for the metals reported in USAF Technical Report 6145-2 have been recalculated to include the enthalpy measurements below 0°C. This procedure changed some values. We believe the present values are more reliable.

Constants A, B, C, and D for the enthalpy equations of the ten metals from the least-squares calculations are given in Table 28. Table 29 lists values for these constants for the seven transparent solids.

Quartic equations were required to fit the enthalpy curves for the materials measured. One equation per material fitted the enthalpy data over the entire temperature testing range, except for SAE 1010 mild steel. Three different equations over different temperature ranges were required for SAE 1010 mild steel because of the magnetic transformation in the temperature range of from about 760 to 770°C.

Table 30 gives values for constants A, "2B", "3C", and "4D" in the specific-heat equations for the ten metals. Table 31 lists the same constants used in the specific-heat equations for the seven transparent solids.

Figures 12 to 28 show specific heats versus temperature for the ten metals and seven transparent solids as calculated from the general equation: $C_p = A + 2Bt + 3Ct^2 + 4Dt^3$, and using the constants listed in Tables 30 and 31.

The various materials and their corresponding figure number are:

K-Monel	Figure 12
Inconel	Figure 13
Inconel X	Figure 14
Stainless steel Type 301	Figure 15
Stainless steel Type 316	Figure 16
Stainless steel Type 347	Figure 17
SAE 1010 mild steel	Figure 18
Magnesium alloy Type AN-M-29	Figure 19
Aluminum alloy Type 24S-T4	Figure 20
Aluminum alloy Type 75S-T6	Figure 21
Clear fused silica (quartz)	Figure 22
Vycor	Figure 23
White (clear) plate glass	Figure 24
Pyrex, clear chemical glass No. 774	Figure 25
Solex "S" plate glass	Figure 26
Solex 2808X plate glass	Figure 27
Plexiglass Type AN-P-44A	Figure 28

TABLE 28. CONSTANTS FOR THE ENTHALPY EQUATION OF TEN METALS FROM THE LEAST-SQUARES CALCULATIONS

Equation: $H_0^t = At + Bt^2 + Ct^3 + Dt^4$ cal. gram^{-1}

Material	Temperature Range, °C.	A	B	C	D
K-Monel	-200 to 850	0.0974	5.984×10^{-5}	-7.964×10^{-8}	5.171×10^{-11}
Inconel	-200 to 850	0.0991	6.232×10^{-5}	-6.954×10^{-8}	4.154×10^{-11}
Inconel X	-200 to 850	0.0999	6.096×10^{-5}	-8.326×10^{-8}	5.808×10^{-11}
Stainless steel Type 301	-200 to 850	0.1065	6.783×10^{-5}	-6.711×10^{-8}	3.075×10^{-11}
Stainless steel Type 316	-200 to 850	0.1052	6.733×10^{-5}	-7.172×10^{-8}	3.555×10^{-11}
Stainless steel Type 347	-200 to 850	0.1045	6.377×10^{-5}	-6.053×10^{-8}	3.006×10^{-11}
SAE 1010 mild steel:	-200 to 700°C.	0.1017	8.203×10^{-5}	-1.023×10^{-7}	1.1039×10^{-10}
	700 to 760°C.*	101.25	2.088×10^{-1}	-1.878×10^{-3}	6.173×10^{-5}
	770 to 850°C.*	89.71	7.166×10^{-1}	-4.833×10^{-3}	1.510×10^{-5}
Magnesium alloy Type AN-M-29	-100 to 350	0.2289	1.189×10^{-4}	-1.428×10^{-7}	1.143×10^{-10}
Aluminum alloy Type 24S-T4	-200 to 450	0.1981	1.262×10^{-4}	-2.242×10^{-7}	2.772×10^{-10}
Aluminum alloy Type 75S-T6	-200 to 450	0.1957	1.252×10^{-4}	-1.871×10^{-7}	2.510×10^{-10}

* The following equation is to be used for SAE 1010 mild steel from 700 to 760°C. and from 770 to 850°C.

$$H_0^t = A + B(t-700) + C(t-700)^2 + D(t-700)^3.$$

TABLE 29. CONSTANTS FOR THE ENTHALPY EQUATION OF SEVEN TRANSPARENT SOLIDS FROM THE LEAST-SQUARES CALCULATIONS

Equation: $H_o^t = At + Bt^2 + Ct^3 + Dt^4$ cal. gram^{-1}

Material	Temperature, Range, °C.	A	B	C	D
Clear fused silica (quartz)	-200 to 800	0.1614	2.167×10^{-4}	-2.078×10^{-7}	9.269×10^{-11}
Vycor	-200 to 800	0.1663	2.165×10^{-4}	-2.777×10^{-7}	1.753×10^{-10}
White (clear) plate glass	-200 to 500	0.1742	2.014×10^{-4}	-1.620×10^{-7}	3.086×10^{-11}
Pyrex Type 774	-200 to 500	0.1695	2.239×10^{-4}	-2.468×10^{-7}	1.163×10^{-10}
Solex "S" plate glass	-200 to 500	0.1726	2.021×10^{-4}	-1.582×10^{-7}	2.389×10^{-11}
Solex 2808X plate glass	-200 to 500	0.1758	1.966×10^{-4}	-1.936×10^{-7}	8.276×10^{-11}
Plexiglass Type AN-P-44A	-200 to 100	0.2875	4.149×10^{-4}	1.151×10^{-6}	4.924×10^{-9}

TABLE 30. CONSTANTS FOR THE SPECIFIC-HEAT EQUATION OF TEN METALS FROM THE DERIVATIVE OF THE ENTHALPY EQUATION

Equation: $C_p = A + 2Bt + 3Ct^2 + 4Dt^3$* cal. gram^{-1} °C.$^{-1}$

Material	Temperature Range, °C.	A	"2B"	"3C"	"4D"
K-Monel	-200 to 850	0.097	1.20×10^{-4}	-2.39×10^{-7}	2.07×10^{-10}
Inconel	-200 to 850	0.099	1.25×10^{-4}	-2.09×10^{-7}	1.66×10^{-10}
Inconel X	-200 to 850	0.100	1.22×10^{-4}	-2.50×10^{-7}	2.32×10^{-10}
Stainless steel Type 301	-200 to 850	0.107	1.36×10^{-4}	-2.01×10^{-7}	1.23×10^{-10}
Stainless steel Type 316	-200 to 850	0.105	1.35×10^{-4}	-2.15×10^{-7}	1.42×10^{-10}
Stainless steel Type 347	-200 to 850	0.105	1.28×10^{-4}	-1.82×10^{-7}	1.20×10^{-10}
SAE 1010 mild steel:	-200 to 700	0.102	1.64×10^{-4}	-3.07×10^{-7}	4.16×10^{-10}
	700 to 760*		0.209	-3.76×10^{-3}	1.85×10^{-4}
	770 to 850*		0.717	-9.69×10^{-3}	4.53×10^{-5}
Magnesium alloy Type AN-M-29	-200 to 350	0.229	2.38×10^{-4}	-4.29×10^{-7}	4.57×10^{-10}
Aluminum alloy Type 24S-T4	-200 to 450	0.198	2.52×10^{-4}	-6.73×10^{-7}	1.11×10^{-9}
Aluminum alloy Type 75S-T6	-200 to 450	0.196	2.50×10^{-4}	-5.61×10^{-7}	1.00×10^{-9}

*The following equation is to be used for SAE 1010 mild steel from 700 to 850°C.:

$$C_p = \text{"2B"} + \text{"3C"}\,(t-700) + \text{"4D"}\,(t-700)^2.$$

TABLE 31. CONSTANTS FOR THE SPECIFIC-HEAT EQUATION OF SEVEN TRANSPARENT SOLIDS FROM THE DERIVATIVE OF THE ENTHALPY EQUATION

Equation: $C_p = A + 2Bt + 3Ct^2 + 4Dt^3$ cal. gram$^{-1}\cdot$C.$^{-1}$

Material	Temperature Range, °C.	A	"2B"	"3C"	"4D"
Clear fused silica (quartz)	-200 to 800	0.161	4.33×10^{-4}	-6.23×10^{-7}	3.71×10^{-10}
Vycor	-200 to 800	0.166	4.33×10^{-4}	-8.33×10^{-7}	7.01×10^{-10}
White (clear) plate glass	-200 to 500	0.174	4.03×10^{-4}	-4.86×10^{-7}	1.23×10^{-10}
Pyrex, Type 774	-200 to 500	0.170	4.48×10^{-4}	-7.41×10^{-7}	6.45×10^{-10}
Solex "S" plate glass	-200 to 500	0.173	4.04×10^{-4}	-4.75×10^{-7}	9.56×10^{-11}
Solex 2808X plate glass	-200 to 500	0.176	3.93×10^{-4}	-5.81×10^{-7}	3.94×10^{-10}
Plexiglass Type AN-P-44A	-200 to 100	0.288	8.30×10^{-4}	3.45×10^{-6}	1.97×10^{-8}

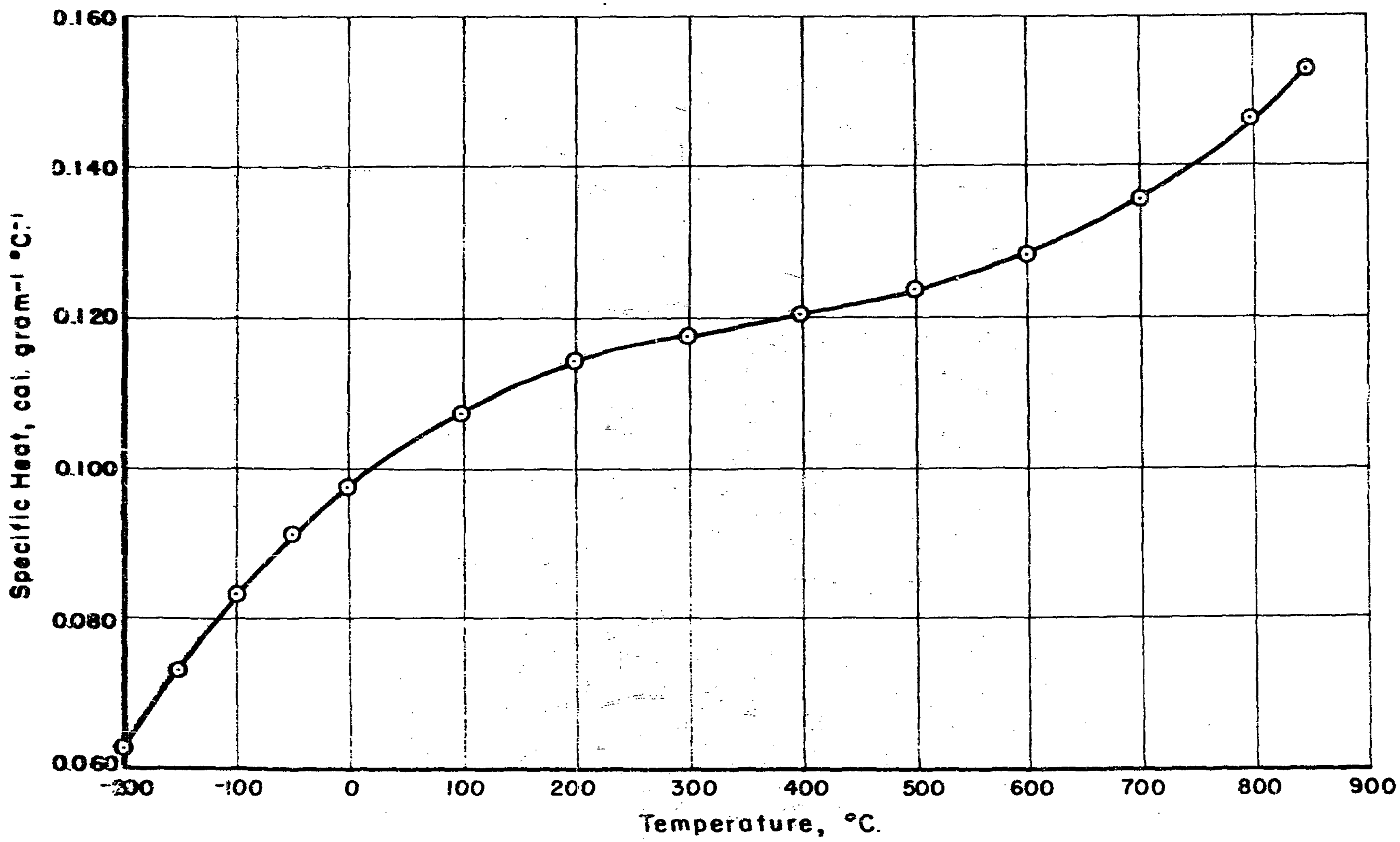

FIGURE 12. SPECIFIC HEAT VERSUS TEMPERATURE FOR K–MONEL

A-9454

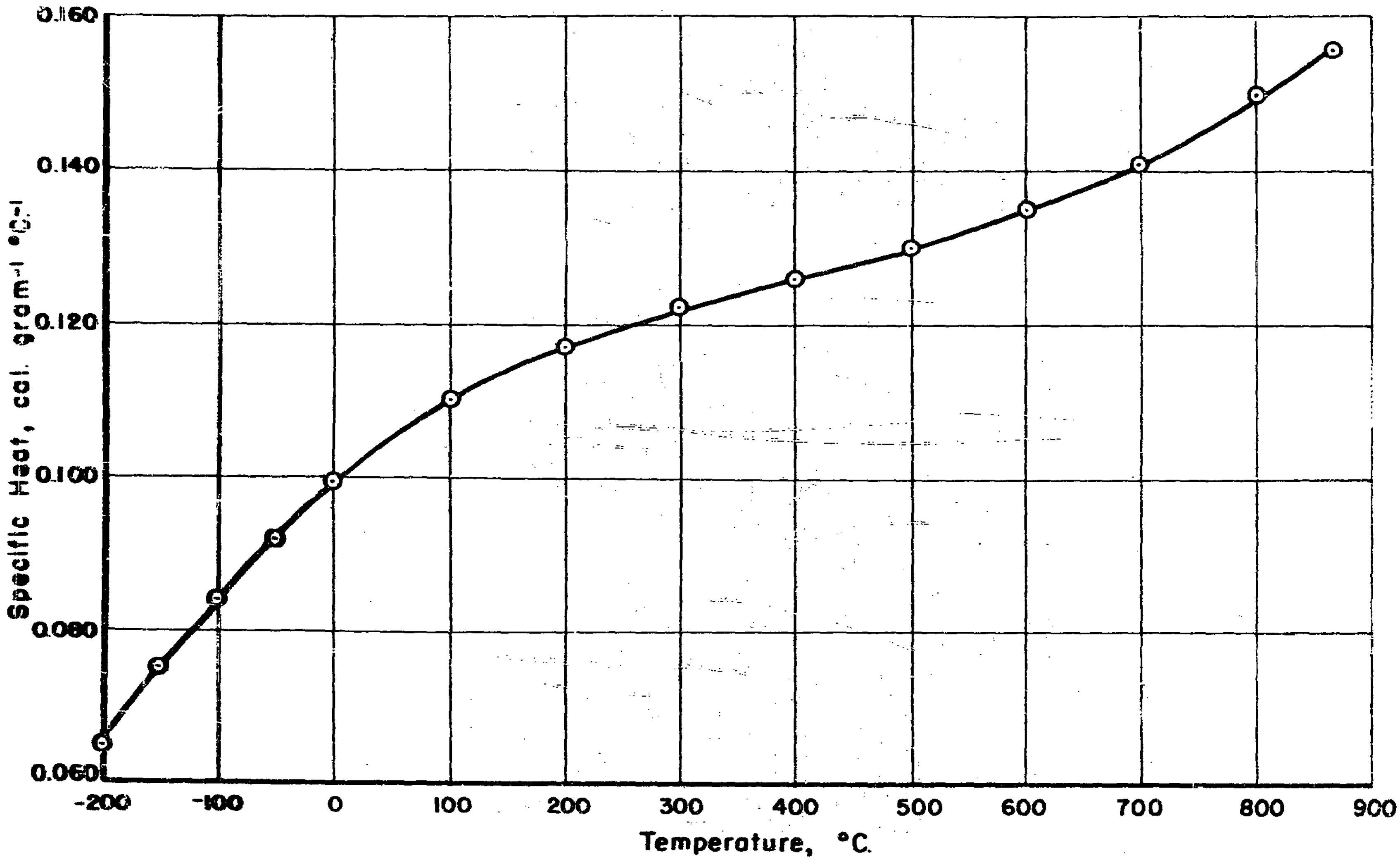

FIGURE 13. SPECIFIC HEAT VERSUS TEMPERATURE FOR INCONEL

A-9453

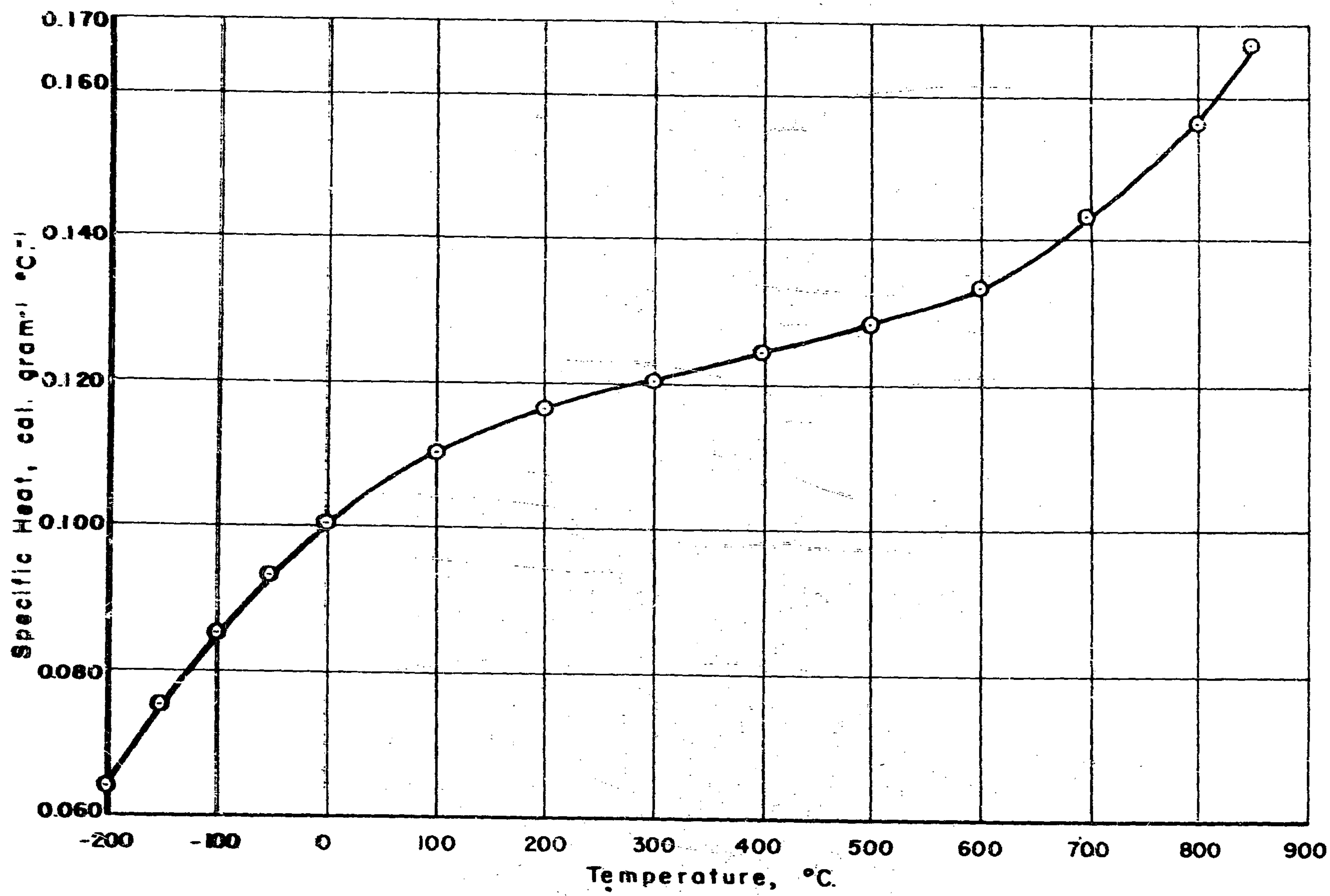

FIGURE 14. SPECIFIC HEAT VERSUS TEMPERATURE FOR INCONEL X

A-9452

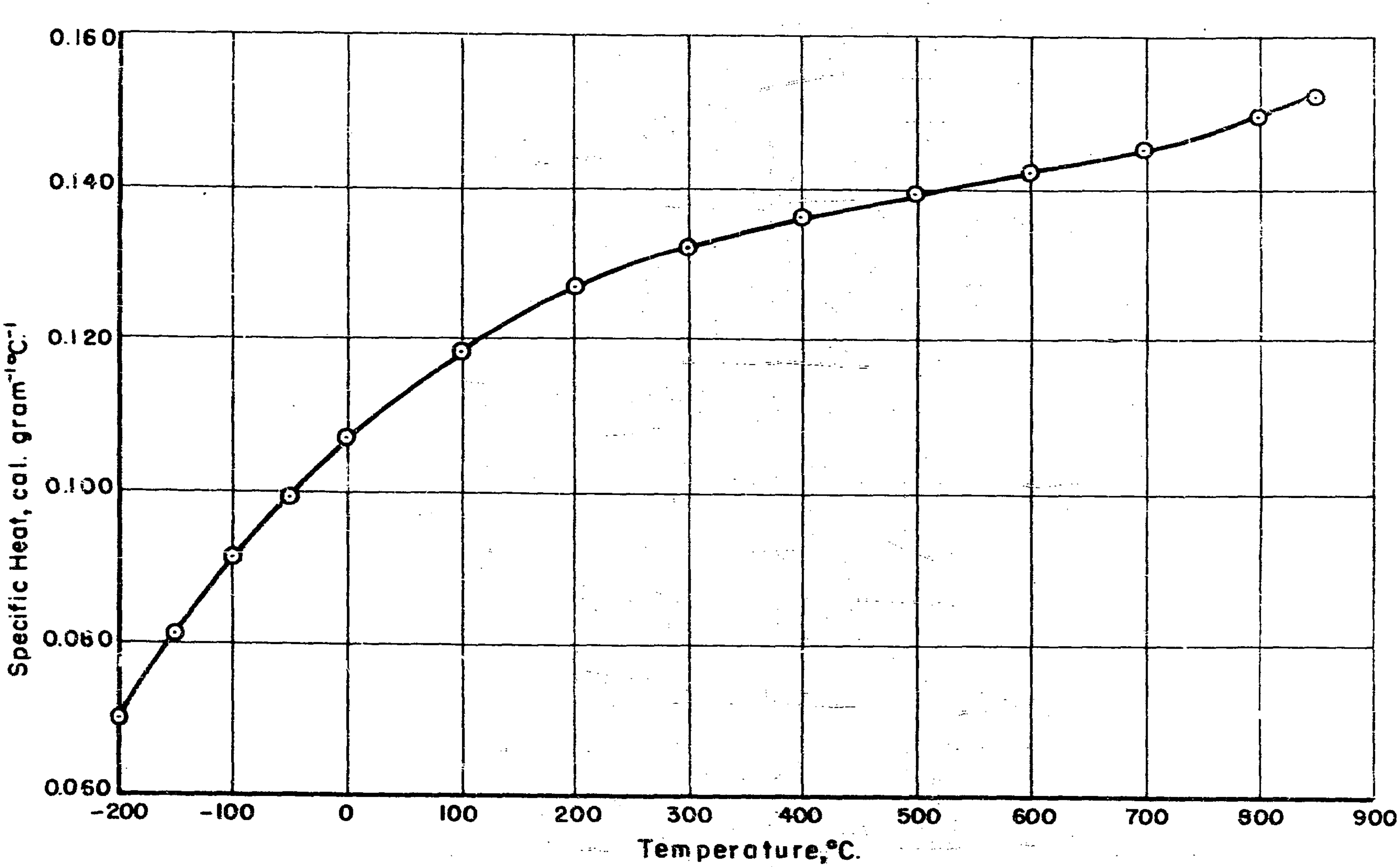

FIGURE 15. SPECIFIC HEAT VERSUS TEMPERATURE FOR STAINLESS STEEL TYPE 301

A-9451

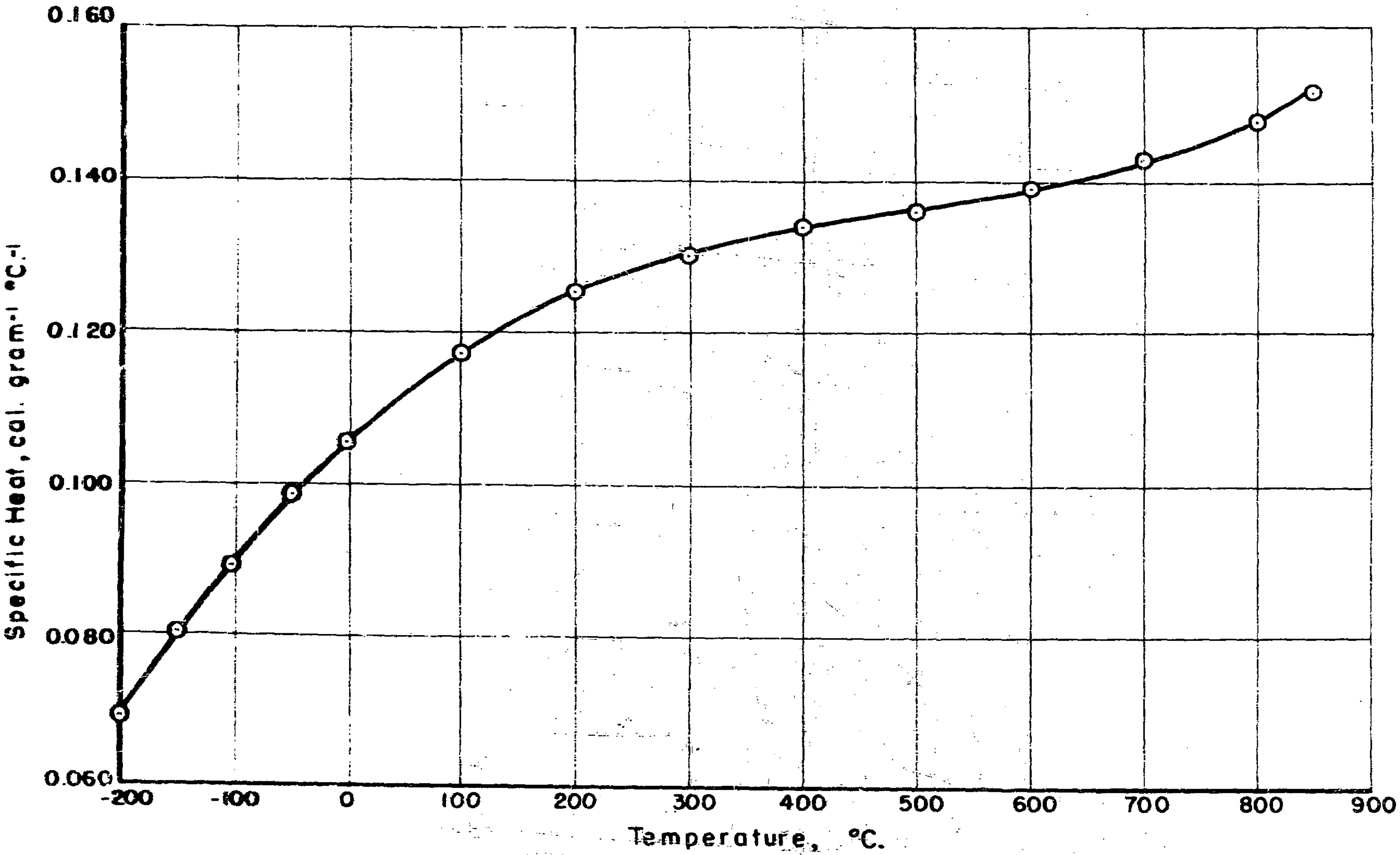

FIGURE 16. SPECIFIC HEAT VERSUS TEMPERATURE FOR STAINLESS STEEL TYPE 316

A-9449

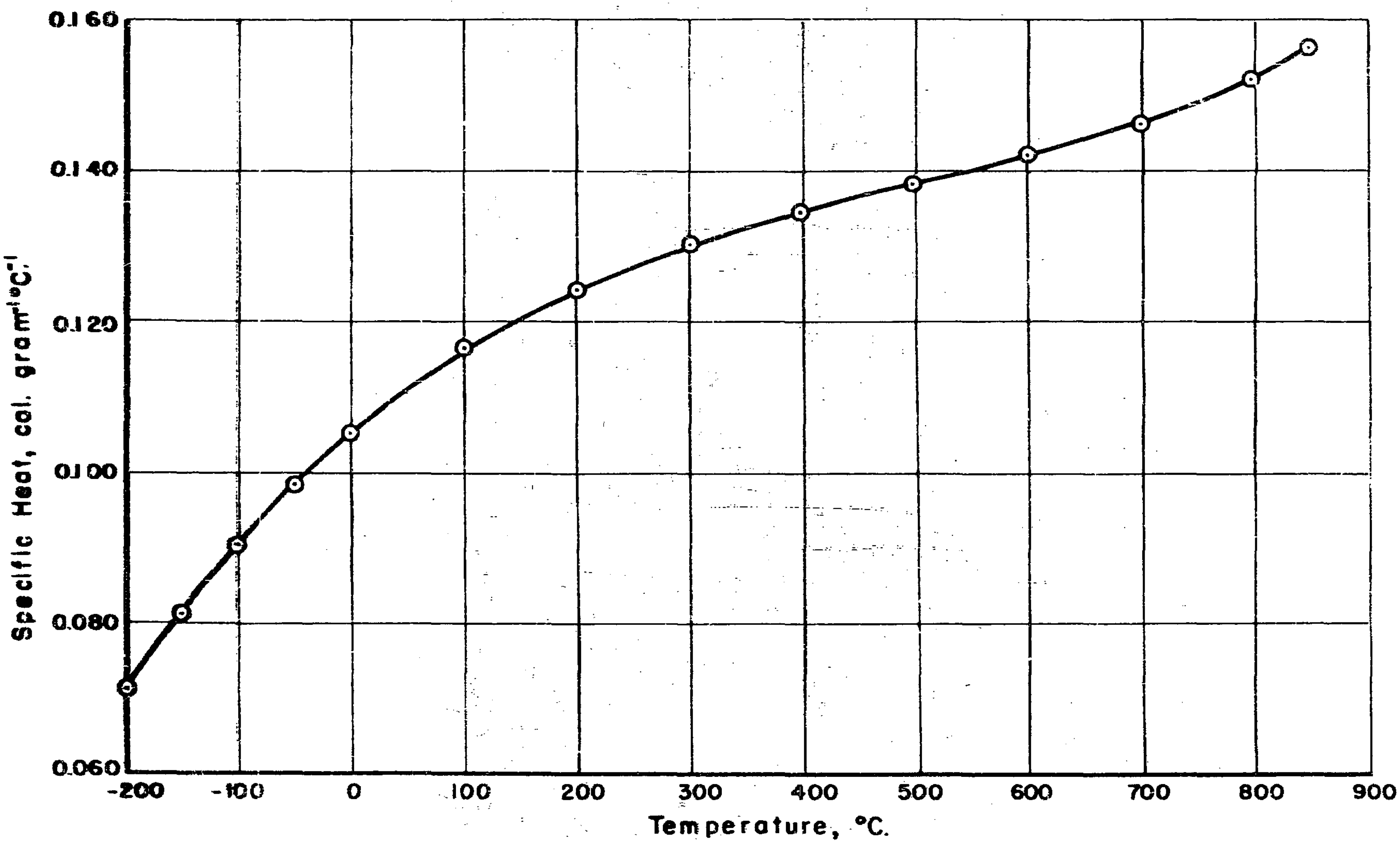

FIGURE 17. SPECIFIC HEAT VERSUS TEMPERATURE FOR STAINLESS STEEL TYPE 347

A-9448

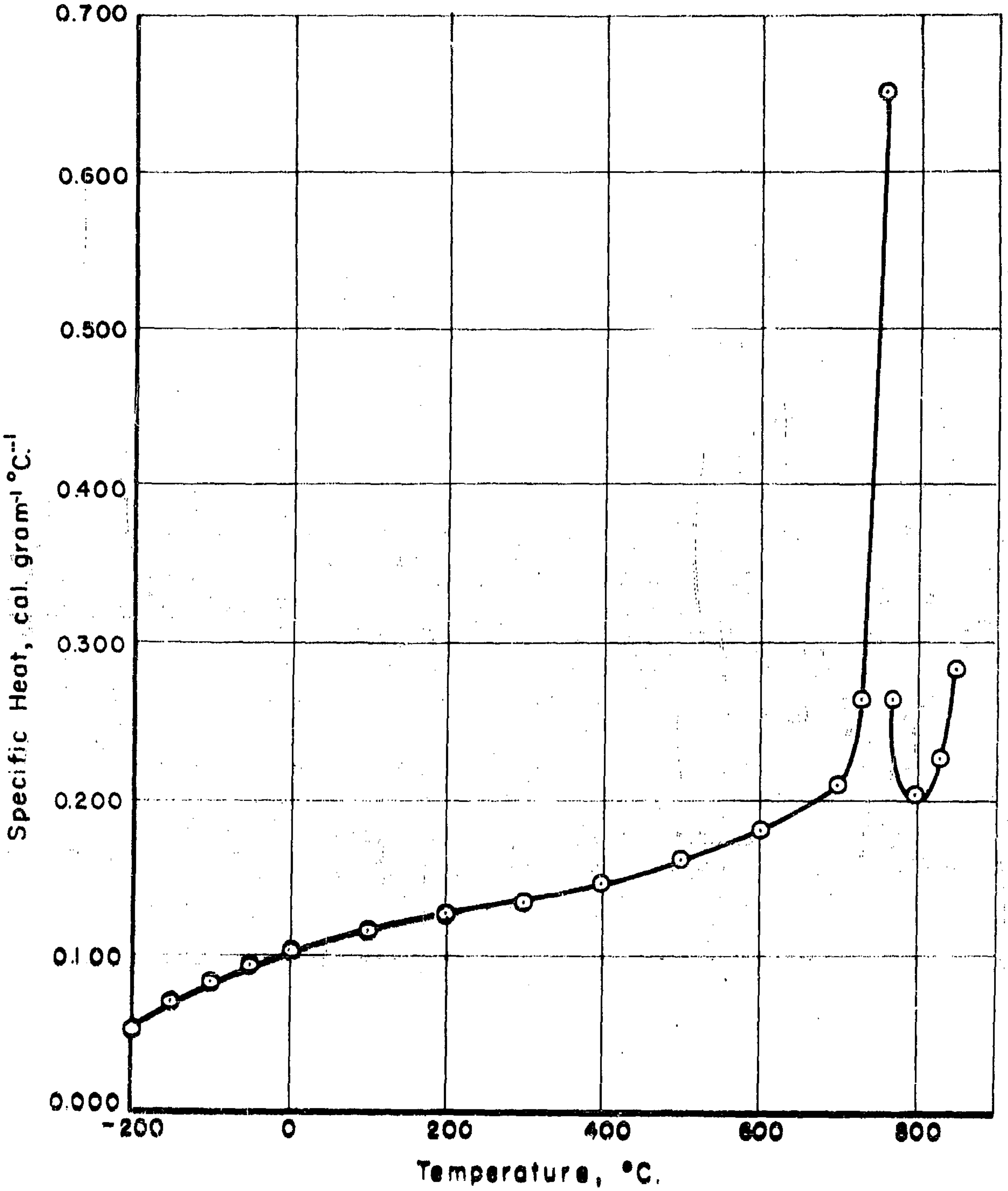

FIGURE 18. SPECIFIC HEAT VERSUS TEMPERATURE FOR SAE 1010 MILD STEEL

A-9447

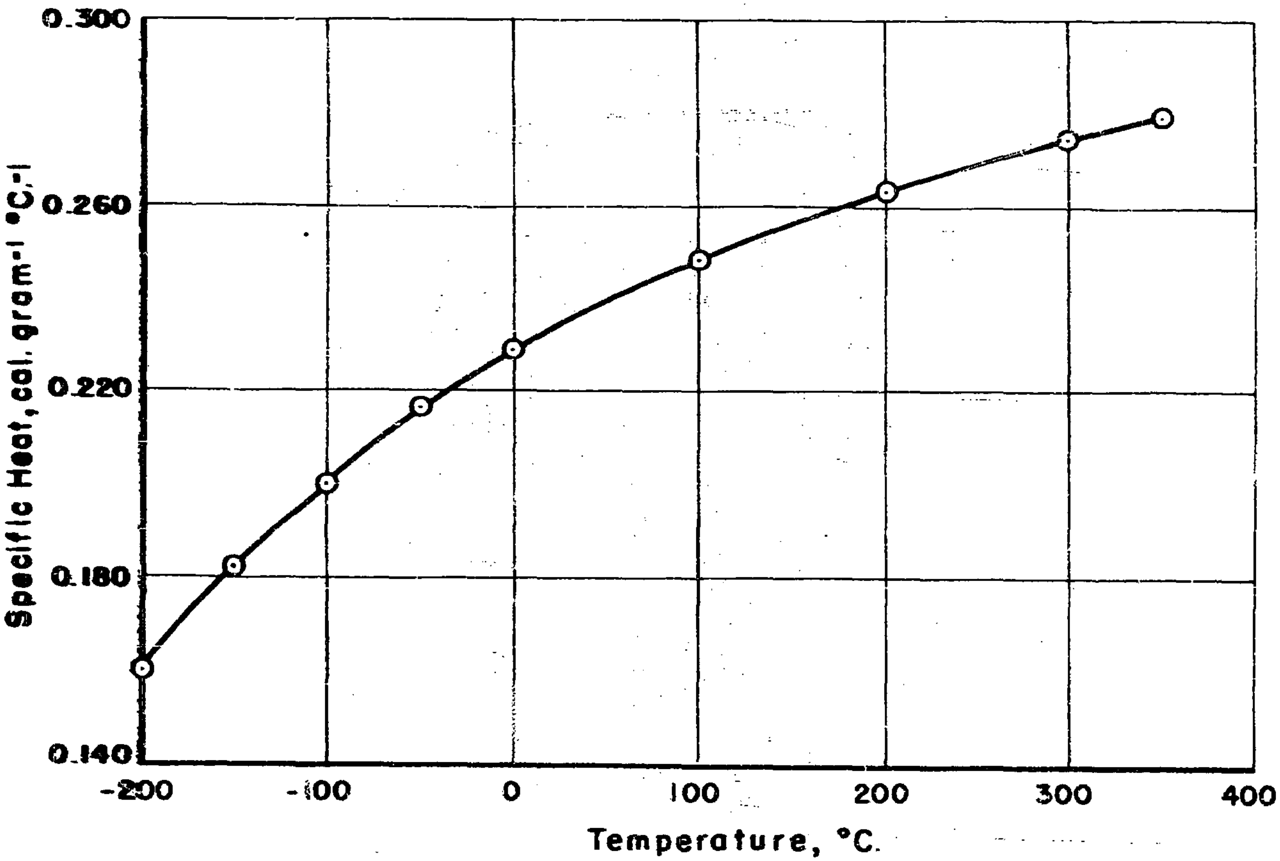

FIGURE 19. SPECIFIC HEAT VERSUS TEMPERATURE FOR MAGNESIUM ALLOY, TYPE AN-M-29

A-9489

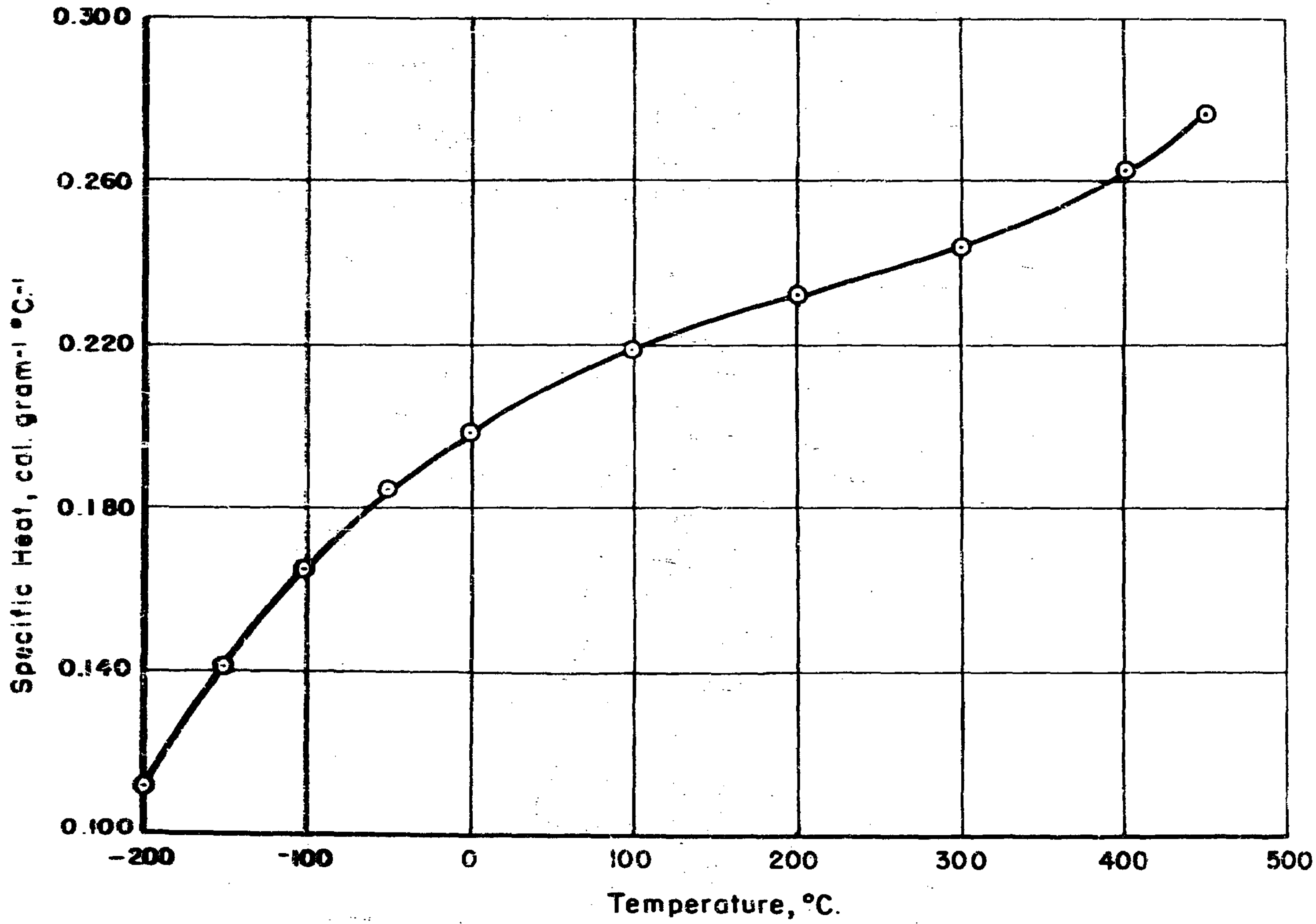

FIGURE 20. SPECIFIC HEAT VERSUS TEMPERATURE FOR ALUMINUM ALLOY, TYPE 24S-T4

A-9467

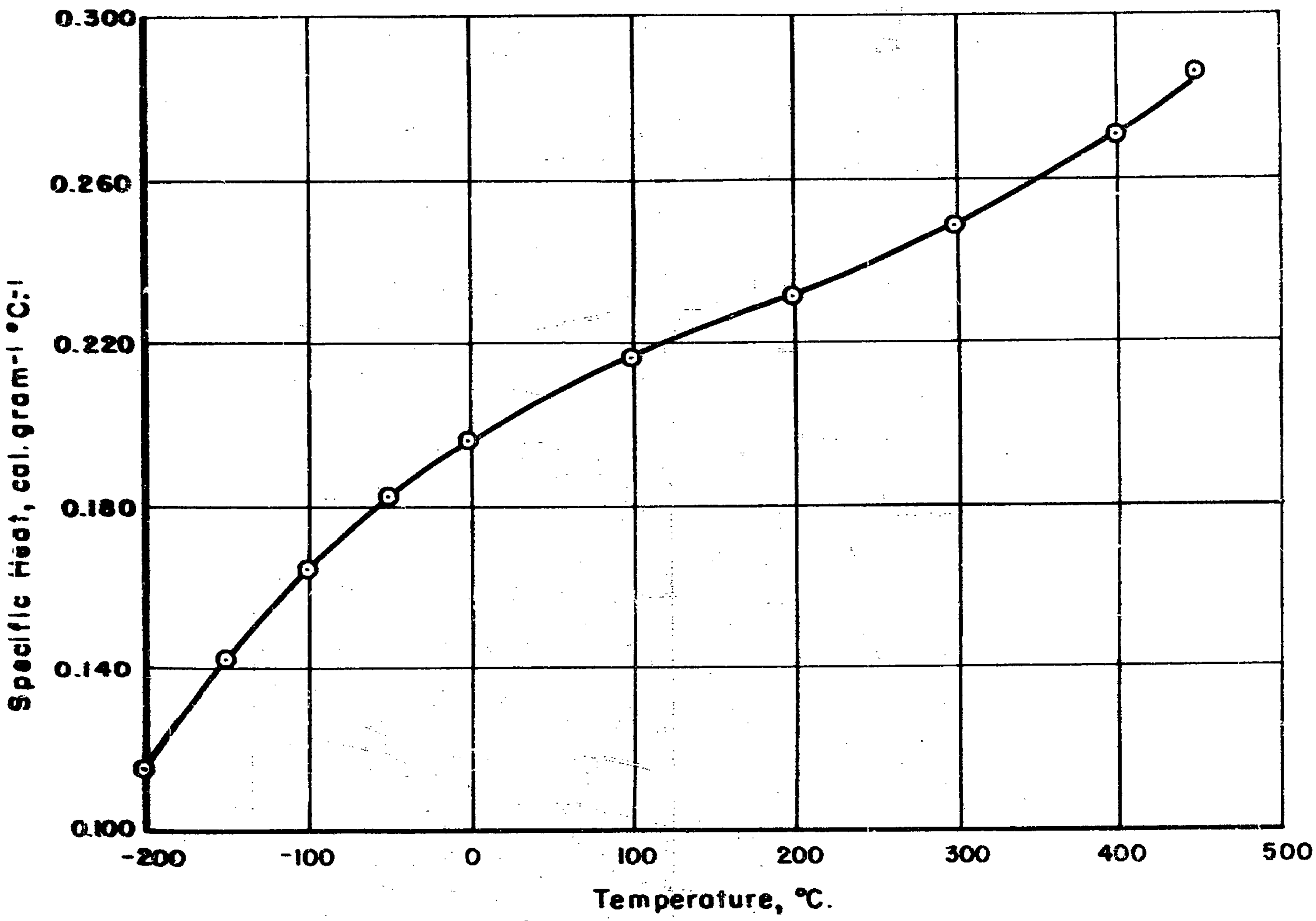

FIGURE 21. SPECIFIC HEAT VERSUS TEMPERATURE FOR ALUMINUM ALLOY, TYPE 75S-T6

A-9465

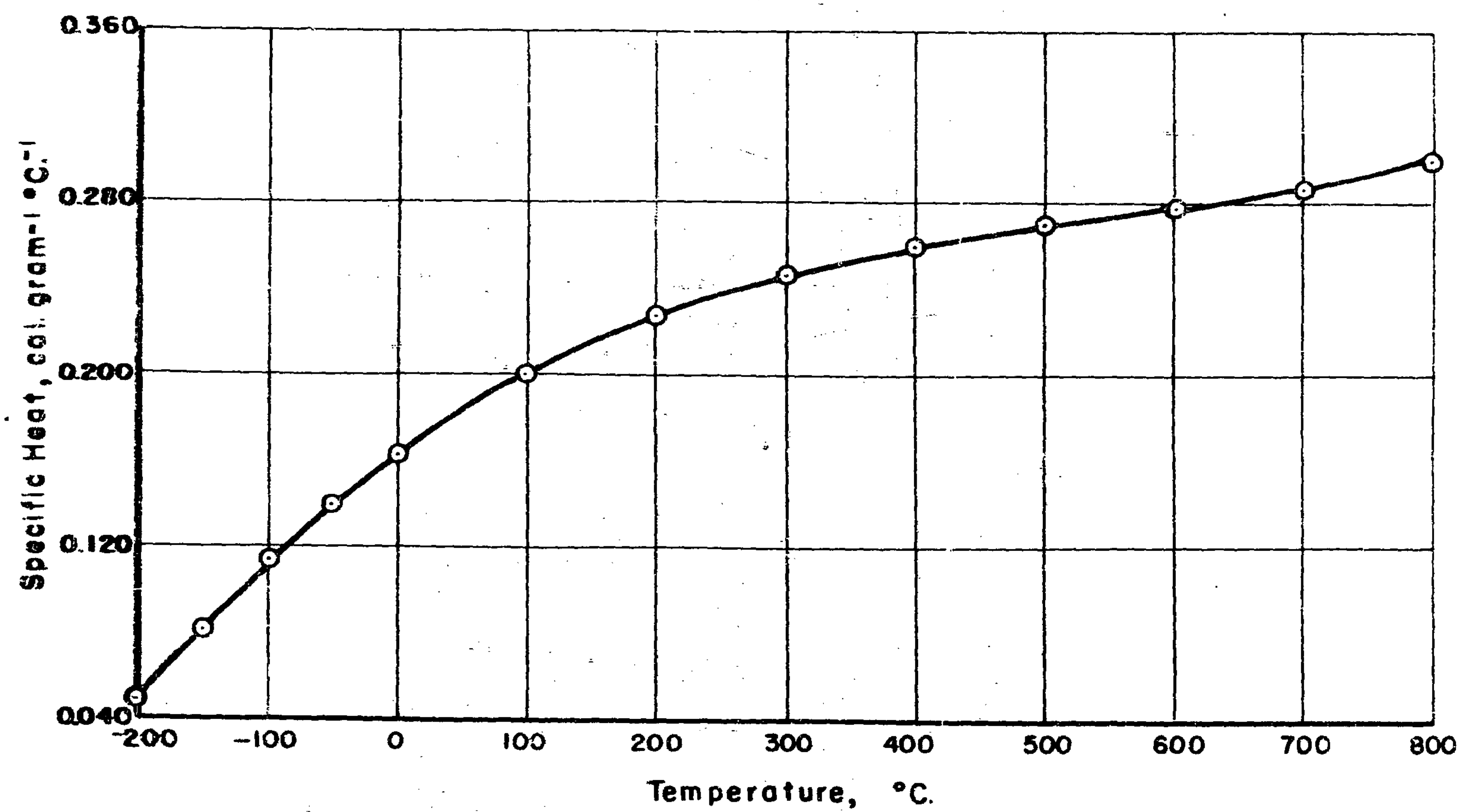

FIGURE 22. SPECIFIC HEAT VERSUS TEMPERATURE FOR CLEAR FUSED SILICA (QUARTZ)

A-9458

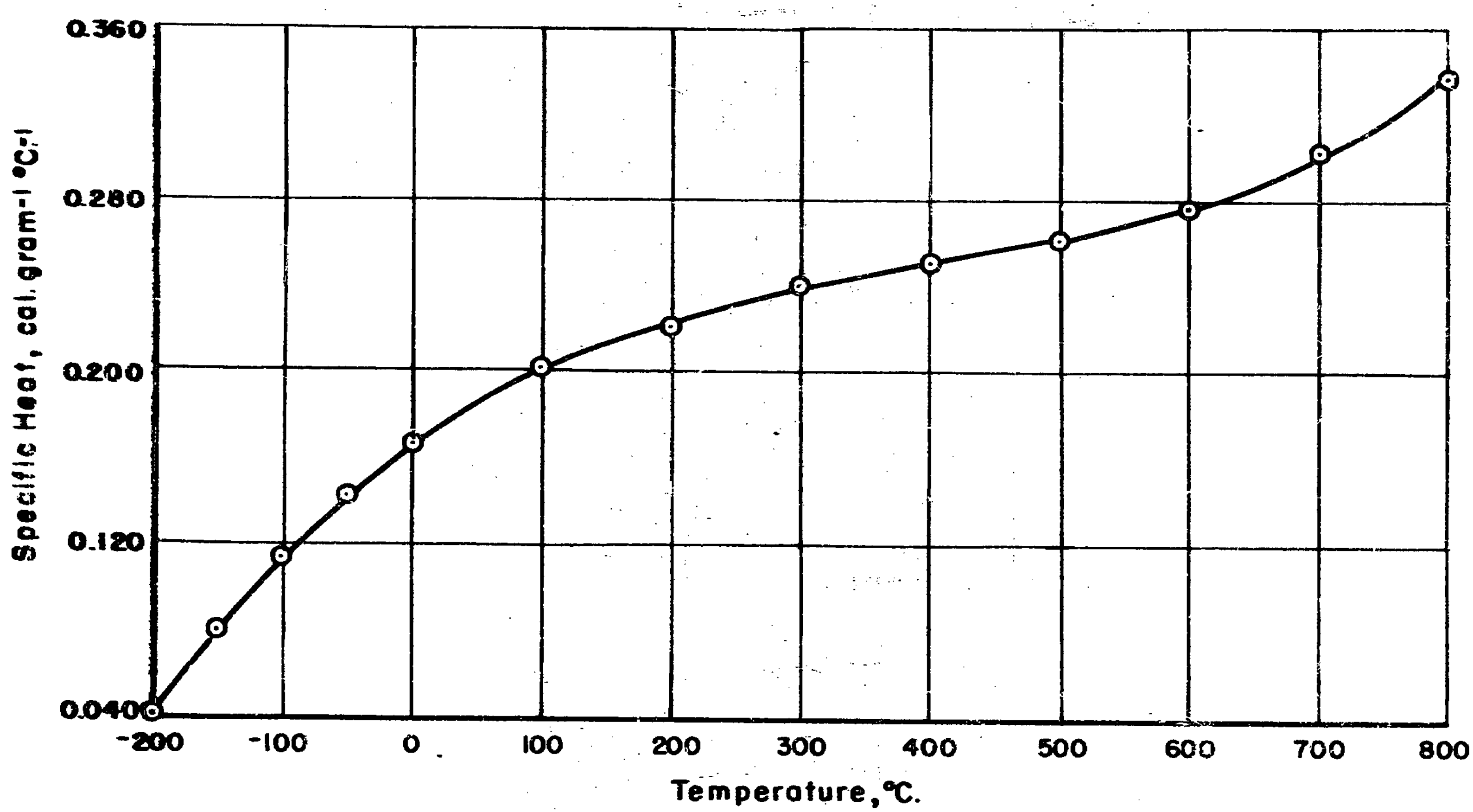

FIGURE 23. SPECIFIC HEAT VERSUS TEMPERATURE FOR VYCOR

A-9465

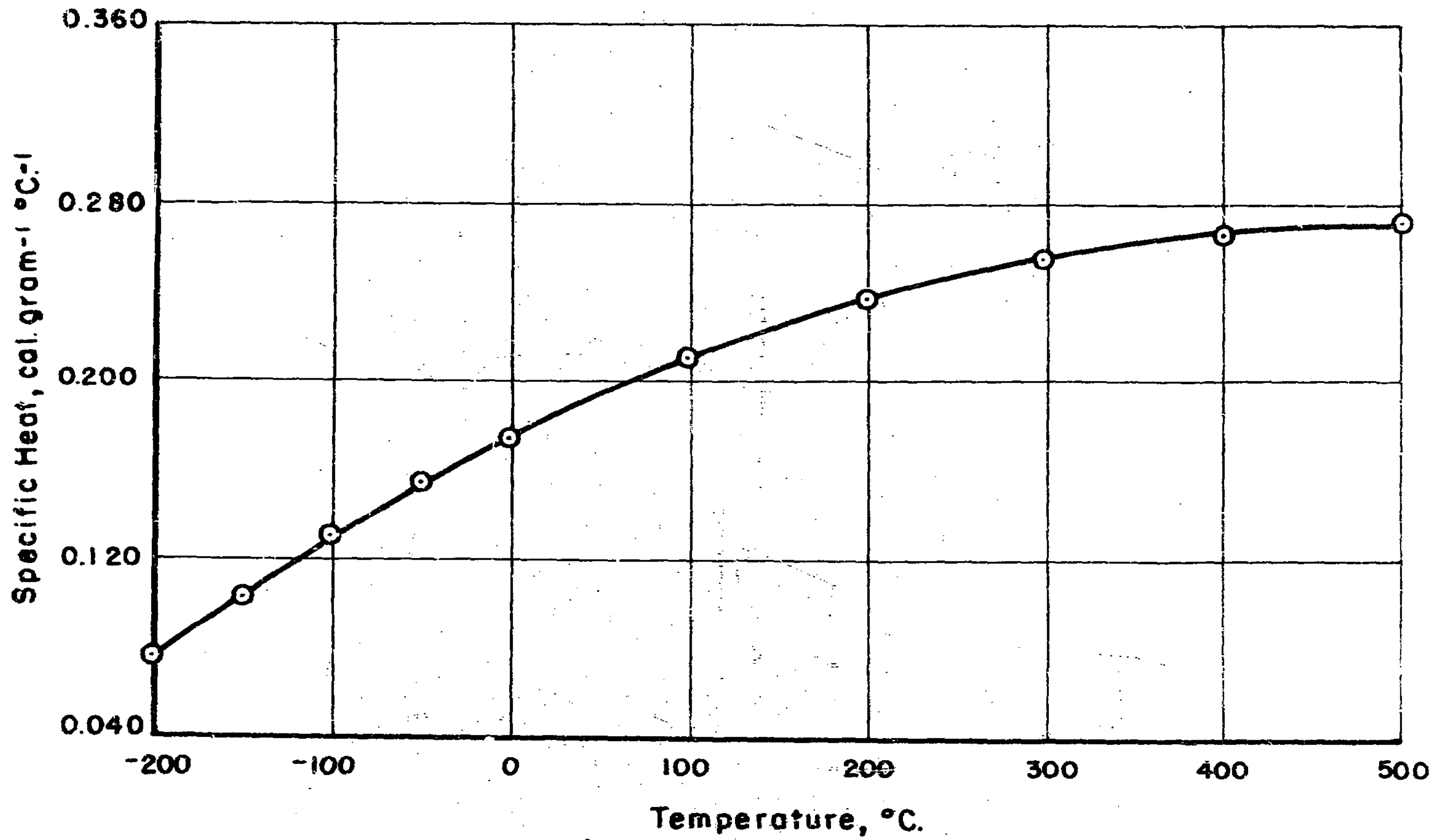

FIGURE 24. SPECIFIC HEAT VERSUS TEMPERATURE FOR WHITE (CLEAR) PLATE GLASS

A-9464

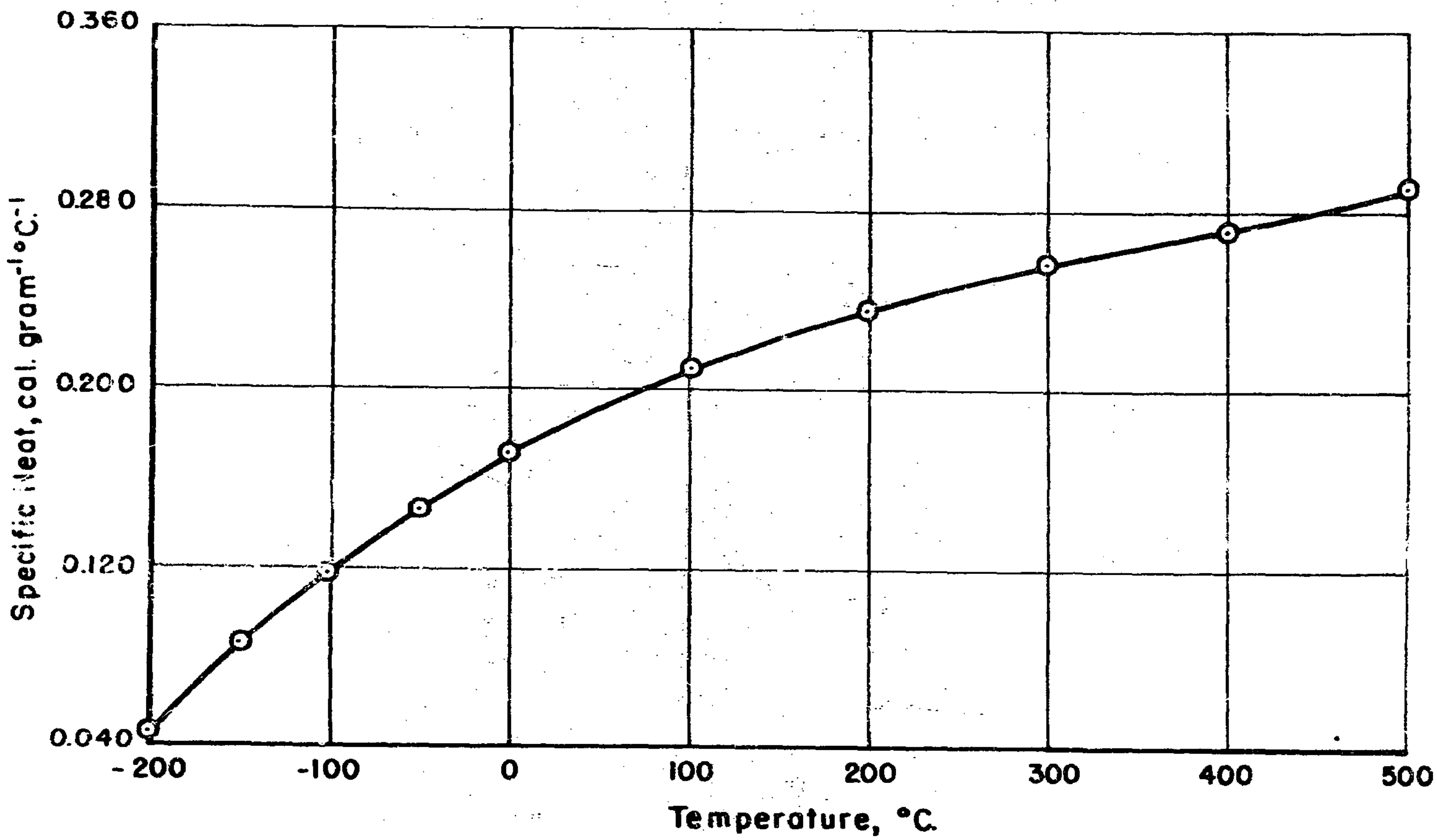

FIGURE 25. SPECIFIC HEAT VERSUS TEMPERATURE FOR PYREX CLEAR CHEMICAL GLASS NO. 774

A-9444

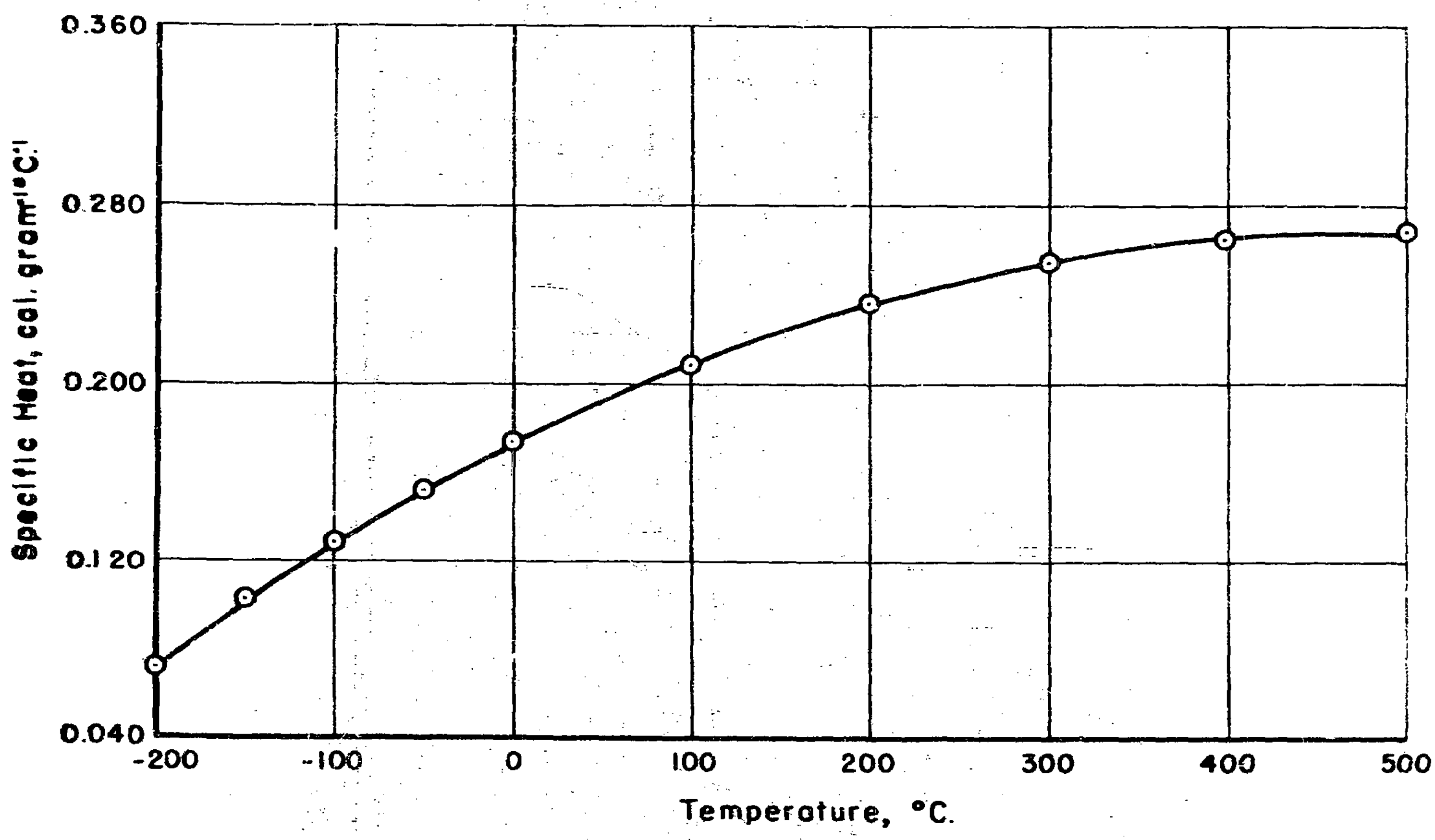

FIGURE 26. SPECIFIC HEAT VERSUS TEMPERATURE FOR SOLEX "S" PLATE GLASS

A-9442

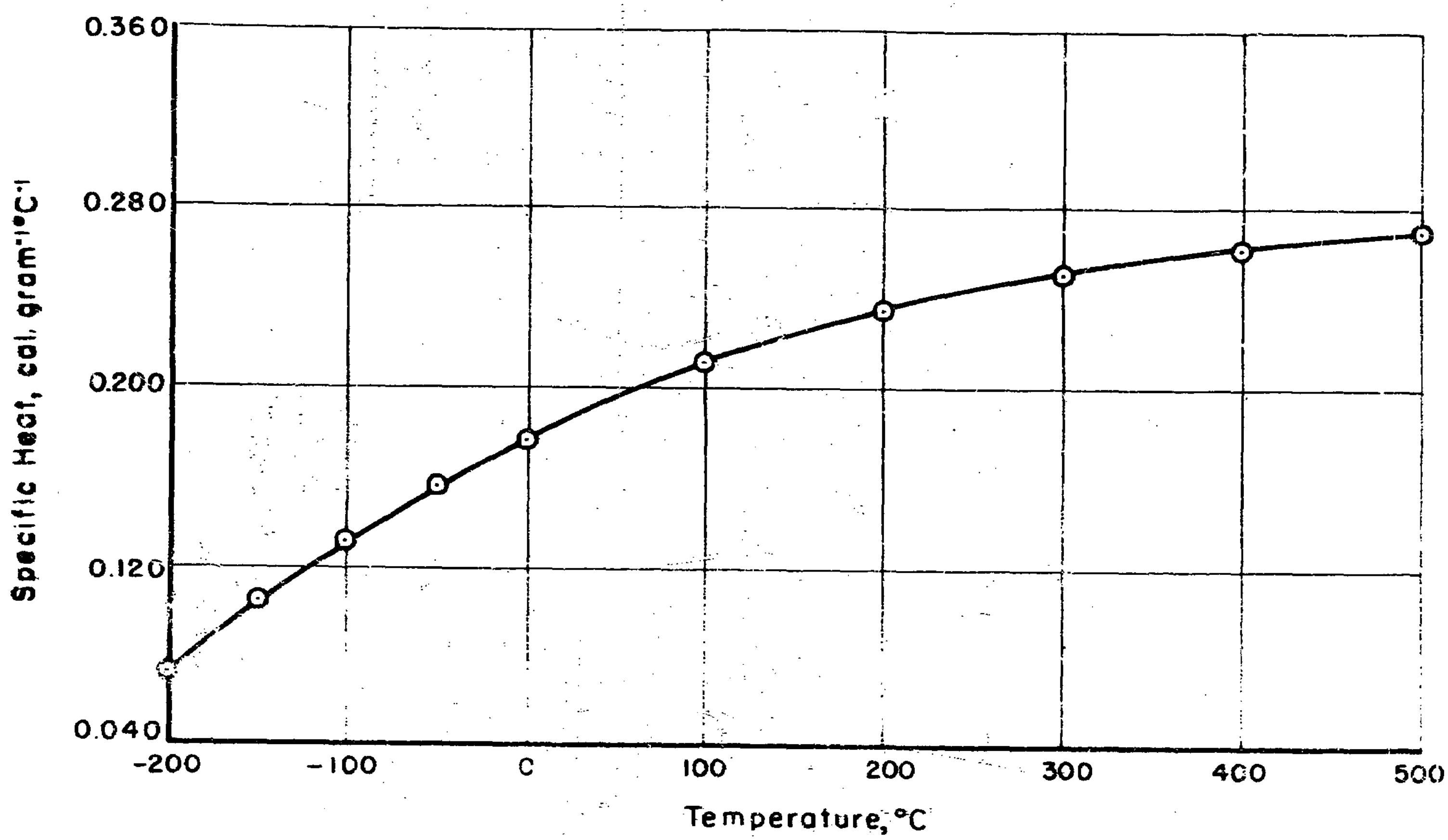

FIGURE 27 SPECIFIC HEAT VERSUS TEMPERATURE FOR SOLEX 2808 X PLATE GLASS

A-9443

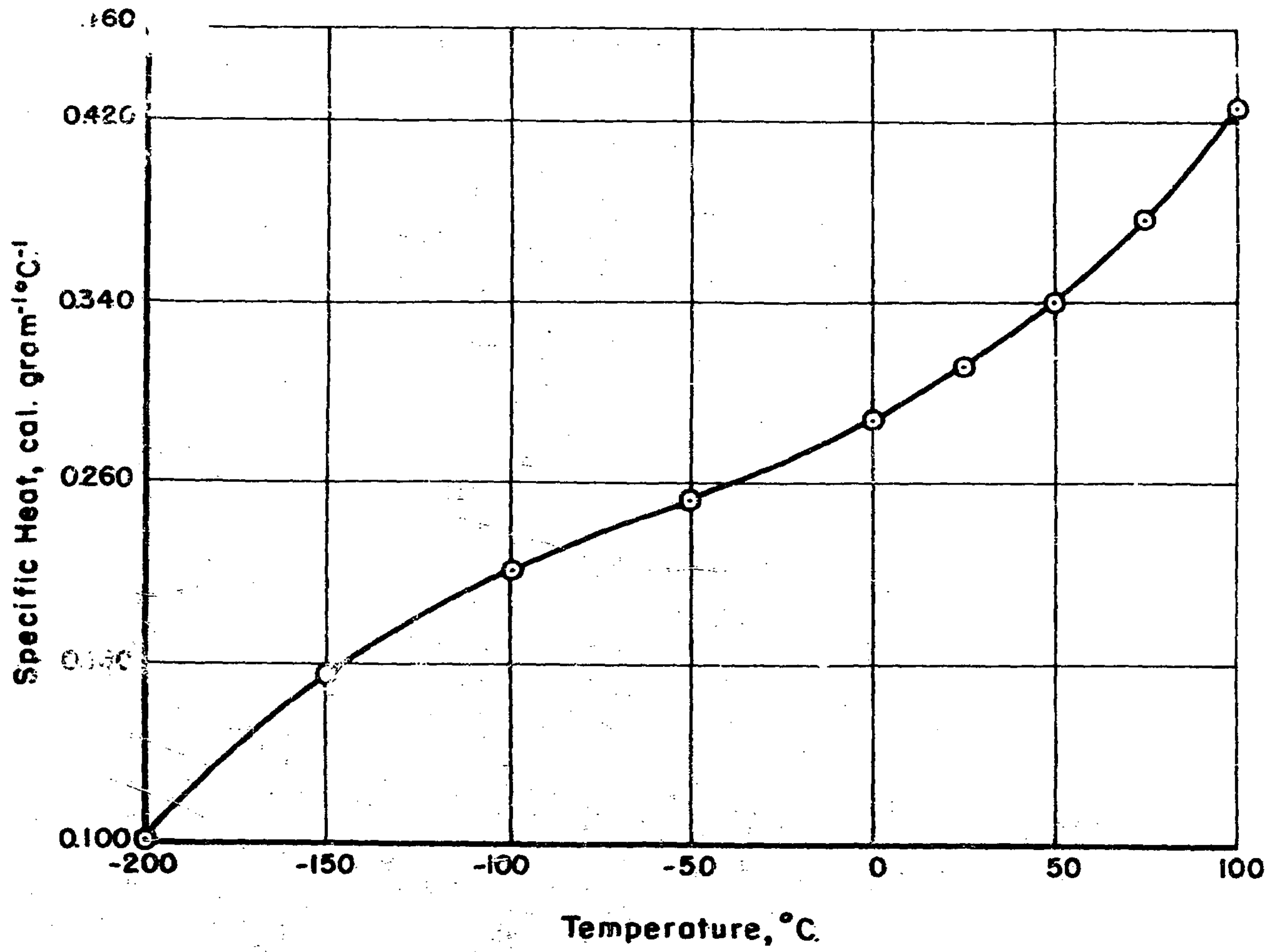

FIGURE 28. SPECIFIC HEAT VERSUS TEMPERATURE FOR PLEXIGLASS TYPE AN-P-44A

A-9441

TABLE 32. SPECIFIC HEATS* OF TEN METALS

Temperature, °C.	K-Monel	Inconel	Inconel X	Stainless Steel Type 301	Stainless Steel Type 316	Stainless Steel Type 347	SAE 1010 Mild Steel	Magnesium Alloy Type AN-M-29	Aluminum Alloy Type 24S-T6	Aluminum Alloy Type 75S-T6
-200	0.062	0.065	0.064	0.070	0.069	0.071	0.053	0.160	0.112	0.115
-150	0.073	0.075	0.075	0.081	0.080	0.081	0.069	0.182	0.141	0.142
-100	0.083	0.084	0.085	0.091	0.089	0.090	0.082	0.200	0.165	0.164
- 50	0.091	0.092	0.093	0.099	0.098	0.098	0.093	0.216	0.184	0.182
0	0.097	0.099	0.100	0.107	0.105	0.105	0.102	0.229	0.198	0.196
100	0.107	0.110	0.110	0.118	0.117	0.116	0.115	0.248	0.218	0.216
200	0.114	0.117	0.116	0.127	0.125	0.124	0.126	0.263	0.231	0.231
300	0.117	0.122	0.120	0.132	0.130	0.130	0.134	0.274	0.243	0.248
350	--	--	--	--	--	--	--	0.279	--	--
400	0.120	0.126	0.124	0.136	0.134	0.134	0.145	--	0.262	0.270
450	--	--	--	--	--	--	--	--	0.276	0.286
500	0.123	0.130	0.128	0.139	0.136	0.138	0.159	--	--	--
600	0.128	0.135	0.133	0.142	0.139	0.142	0.179	--	--	--
700	0.135	0.141	0.143	0.145	0.143	0.146	0.209	--	--	--
730	--	--	--	--	--	--	0.263	--	--	--
760	--	--	--	--	--	--	0.650	--	--	--
770	--	--	--	--	--	--	0.262	--	--	--
800	0.146	0.150	0.156	0.149	0.148	0.152	0.203	--	--	--
830	--	--	--	--	--	--	0.226	--	--	--
850	0.153	0.156	0.167	0.152	0.152	0.156	0.283	--	--	--

* Specific heat is tabulated in cal. $gram^{-1} \cdot C^{-1}$

TABLE 33. SPECIFIC HEATS* OF SEVEN TRANSPARENT SOLIDS

Temperature, °C.	Clear Fused Silica (Quartz)	Vycor	White (Clear) Plate Glass	Pyrex Type 774	Solex "S" Plate Glass	Solex 2808X Plate Glass	Plexiglass Type AN-P-44A
-200	0.047	0.041	0.075	0.045	0.072	0.071	0.102
-150	0.081	0.080	0.102	0.084	0.101	0.103	0.174
-100	0.112	0.114	0.129	0.117	0.127	0.130	0.219
- 50	0.138	0.142	0.153	0.145	0.151	0.155	0.252
0	0.161	0.166	0.174	0.170	0.173	0.176	0.288
25	--	--	--	--	--	--	0.311
50	--	--	--	--	--	--	0.340
75	--	--	--	--	--	--	0.377
100	0.199	0.202	0.210	0.208	0.208	0.210	0.425
200	0.226	0.221	0.236	0.235	0.235	0.234	--
300	0.245	0.240	0.255	0.255	0.254	0.251	--
400	0.259	0.251	0.266	0.271	0.264	0.262	--
500	0.269	0.262	0.270	0.289	0.268	0.271	--
600	0.277	0.277	--	--	--	--	--
700	0.286	0.302	--	--	--	--	--
800	0.299	0.338	--	--	--	--	--

* Specific heat is tabulated in cal. gram^{-1} °C.$^{-1}$.

TABLE 34. COMPARISON OF SPECIFIC HEATS

Material	Temperature Range, °C.	Specific Heat, cal. $gram^{-1}$ °$C.^{-1}$ From Observed Enthalpy Data	Specific Heat, cal. $gram^{-1}$ °$C.^{-1}$ Reported in Literature	Reference
K-Monel	25-400	0.116	0.127	Phys. Const. Int'l. Nickel Co. 1947, page 4
Inconel	25-100	0.116	0.109	Phys. Const. Int'l. Nickel Co. 1947, page 4
Inconel X	20-900	0.13	0.13	Tech. Bull. T7, Int'l. Nickel Co. Mar. '50, page 21
Stainless steel Type 316	0-100	0.11	0.12	ASM Handbook 1948, page 566
Stainless steel Type 347	0-100	0.11	0.12	ASM Handbook 1948, page 566
Magnesium alloy Type AN-M-29	0-25	0.23	0.25	ASM Handbook 1948, page 1021
Aluminum alloy Type 24S-T4	0-100	0.21	0.23	ASM Handbook 1948, page 817
Aluminum alloy Type 75S-T6	0-100	0.21	0.23	ASM Handbook 1948, page 823
Pyrex, Type 774	0-100	0.17	0.20	Int'l. Critical Tables 1927, V. 2, page 93

Table 32 lists specific-heat values for the ten metals at selected temperatures. Table 33 lists specific-heat values at selected temperatures for the seven transparent solids.

Table 34 shows a comparison of some specific-heat-values obtained from the observed enthalpy data with specific-heat values found in the literature.

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(1) Lucks, C. F., et al., "The Experimental Measurement of Thermal Conductivities, Specific Heats, and Densities of Metallic, Transparent, and Protective Materials, Part I", United States Air Force Technical Report No. 6145-1, February, 19[illegible]1.

(2) Lucks, C. F., et al., "The Experimental Measurement of Thermal Conductivities, Specific Heats, and Densities of Metallic, Transparent, and Protective Materials, Part 2", United Air Force Technical Report No. 6145-2, July, 1952.

(3) Van Dusen, M. S., and Shelton, S. M., "Apparatus for Measuring Thermal Conductivity of Metals up to 600°C," Natl. Bur. Standards (U. S.), J. Res., Res. Paper 668, 12 (193[illegible]), pp. [illegible].

(4) Kellett, B. S., "The Steady Flow of Heat Through Hot Glass", J. Opt. Soc. Am., 42 (1952), pp. 339-343.

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(6) Ginnings, D. C., and Furukawa, G. T., "Heat Ca[illegible] for the Range 14 to 1200°K.", J. Am. Chem. Soc. 75 (195[illegible]), p. 525.

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CFL:JM:JAV/NLC